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Development and Integration of Critical Reasoning Assessment in Science Learning: A Systematic Literature Review

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Abstract: Critical reasoning is an important ability in science learning because it relates to students' capacity to analyze information, evaluate evidence, and make decisions based on logical reasons. The relationships among critical reasoning assessment, learning integration, ecosystem material, and local wisdom contexts have rarely been examined in an integrated way. This study aims to map the development of critical reasoning research in science education and to identify research gaps as a basis for developing a critical reasoning assessment device integrated with local-wisdom-based ecosystem learning. The method used was a Systematic Literature Review following PRISMA 2020. From 200 articles in RIS format, 19 relevant articles were identified and 3 were excluded, so 16 articles were synthesized; a bibliometric analysis was conducted using VOSviewer. The results show that previous studies have developed critical reasoning assessments, learning devices, socioscientific-issue approaches, ecological contexts, and local wisdom, but generally examined these components separately. These findings open opportunities to integrate critical reasoning assessment with science learning on ecosystem material through authentic local wisdom contexts.

Keywords: Assessment; Critical reasoning; Local wisdom; Science learning; Systematic literature review

Introduction

Critical reasoning is an important ability in science learning because it enables students to use information and evidence to analyze a problem, evaluate information, identify relationships among components, and draw conclusions supported by logical reasons. Critical thinking is commonly described as reasonable, reflective thinking focused on deciding what to believe or do (Ennis, 2018). In science learning, this ability is needed because understanding scientific phenomena depends not only on mastering facts and concepts but also on students' ability to use evidence, connect pieces of information, and justify a conclusion. Therefore, the development of critical reasoning should become part of the learning process and should also receive attention in the assessment systems used to identify students' reasoning abilities.

Recent research shows that critical reasoning assessment in science learning has begun to move toward the development of instruments with specific characteristics and contexts. Ekawati et al. (2024), for example, developed a critical reasoning assessment instrument as a diagnostic assessment in physics learning using polytomous scoring. The development involved expert validation and trials with students to obtain an instrument that can be used to identify critical reasoning ability. Other studies have also developed critical reasoning instruments based on socioscientific issues, which cover the abilities to evaluate information, identify the complexity of an issue, examine the credibility of information sources, and consider the perspectives of different parties. Socioscientific issues have long been recognized as a rich context for examining students' informal reasoning (Sadler, 2004). These findings indicate that critical reasoning assessment is developing from the measurement of general ability toward instruments built around the characteristics of specific tasks and learning contexts.

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In addition to instrument development, critical reasoning research has also begun to connect assessment with the learning process. Setiowati et al. (2025), for example, integrated authentic e-assessment into ecology and biodiversity learning through the STEAMRel-PBL model to examine students' critical reasoning. This shows that critical reasoning assessment can be used not only as a measurement tool at the end of learning but also within learning environments in which students demonstrate their reasoning through authentic tasks and activities. Nevertheless, research on integrating critical reasoning assessment with the learning process still varies in the form of assessment, the characteristics of the tasks, and the degree of connection between learning activities and the reasoning evidence produced by students.

The context of the learning material is also an important aspect in developing critical reasoning assessment. Ecosystem material has characteristics that allow students to deal with complex phenomena and cause-and-effect relationships between biotic and abiotic components. Students can use evidence to analyze interactions among ecosystem components, energy flow, organism diversity, environmental change, and the impact of human activities on ecosystem balance. These characteristics offer opportunities to design assessment tasks that not only evaluate concept mastery but also reveal how students analyze information, evaluate evidence, make inferences, and provide reasons for ecological problems. Research that places critical reasoning assessment in ecology learning indicates that ecological contexts have potential for developing and measuring students' reasoning.

In addition to the context of the material, local wisdom has important potential in science learning because it can connect scientific knowledge with the knowledge, values, experiences, and practices that develop in community life. Integrating local wisdom allows students to learn scientific phenomena through an environment and culture that is closer to their lives, and indigenous and local knowledge has been argued to enrich science education, particularly for sustainability (Zidny et al., 2020). In ecosystem learning, local wisdom related to the environment can become a source of problems and information that enables students to compare knowledge, analyze the relationship between human activities and the environment, evaluate information, and draw conclusions based on evidence. Thus, local wisdom serves not only as a setting or location for learning but can also be used as part of the learning context and as a source of evidence in the critical reasoning process.

Although research on critical reasoning assessment, contextual learning, and the integration of local wisdom has developed, these three aspects have rarely been synthesized specifically within a single assessment framework. Previous studies tend to focus on developing and validating critical reasoning instruments, using assessment in particular learning contexts, or utilizing local wisdom as a learning resource. This condition indicates a need to understand how critical reasoning assessment is developed, which indicators are used, how assessment is integrated with the learning process, and to what extent local wisdom is utilized in the design of such assessment. Mapping previous research is therefore necessary to identify patterns, trends, and limitations that can serve as a basis for developing critical reasoning assessment devices that are more contextual and integrated with learning.

Based on these conditions, a systematic literature review that specifically focuses on critical reasoning in science learning assessment is needed. This review does not treat critical thinking as a construct identical to critical reasoning; instead, it specifically examines studies that explicitly develop, measure, or apply critical reasoning in the context of science education. Accordingly, this systematic literature review aims to (1) identify the characteristics of research on critical reasoning assessment in science learning, (2) analyze the forms and characteristics of the instruments used to measure critical reasoning, (3) identify the indicators or dimensions of critical reasoning used in previous research, (4) analyze how critical reasoning assessment is integrated with the learning process, (5) identify how local wisdom is utilized in critical reasoning learning and assessment, and (6) identify research gaps as a basis for developing a critical reasoning assessment device integrated with local-wisdom-based ecosystem learning.

Method

Research Design

This study used the Systematic Literature Review (SLR) method to identify, evaluate, and synthesize previous research on critical reasoning assessment in science learning. An SLR was chosen because it allows research evidence to be identified systematically, articles to be selected based on predetermined criteria, and the characteristics and trends of research relevant to the focus of the review to be synthesized with explicit and replicable procedures (Tranfield et al., 2003). The reporting of the review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guideline (Page et al., 2021) so that the identification, screening, eligibility assessment, and inclusion of articles are reported transparently.

This review specifically limits the construct under study to critical reasoning. Articles that used only the term critical thinking without a clear conceptual or

operational relationship to critical reasoning were not used as primary evidence in the synthesis. This restriction was applied to maintain construct consistency and to avoid equating critical reasoning with critical thinking during the literature synthesis.

Research Questions

Based on the aims of the study, this SLR was designed to answer the following research questions:

RQ1. How is critical reasoning conceptualized and operationalized in science education research?
RQ2. What are the characteristics of the instruments or assessment devices used to measure critical reasoning in science learning?
RQ3. Which critical reasoning indicators or dimensions are most widely used in previous research?
RQ4. How is critical reasoning assessment integrated with the science learning process?
RQ5. How is local wisdom utilized in critical reasoning learning or assessment development?
RQ6. What research gaps can serve as a basis for developing a critical reasoning assessment device integrated with local-wisdom-based ecosystem learning?

Search Strategy

The literature search targeted scientific articles relevant to a combination of keywords related to three main groups: critical reasoning, assessment, and science education. The keywords were developed by considering the variations in terms used in previous research.

The main keyword combination used was:

"critical reasoning" AND assessment AND "science education"

In addition, the search was expanded using the following combinations:

"critical reasoning" AND assessment AND science learning
"critical reasoning" AND "assessment instrument"
"critical reasoning" AND "local wisdom"
"critical reasoning" AND "local knowledge" AND science
"critical reasoning" AND ecosystem
"critical reasoning" AND biology

This search strategy was used to obtain studies that not only discuss the measurement of critical reasoning but also connect this ability with science learning, ecosystem material, and local wisdom.

Eligibility Criteria

Articles identified through the search were selected based on inclusion and exclusion criteria that were set before the synthesis.

Inclusion criteria

An article was included in the SLR if it met the following criteria:

1. it is a scientific research article published in a journal;
2. it addresses critical reasoning as a construct that is explicitly mentioned or defined;
3. it is related to science education or science learning;
4. it addresses assessment, instruments, tests, rubrics, or devices used to identify or measure critical reasoning;
5. information is available that allows the characteristics of the study to be analyzed;
6. the article is available in full text;
7. the article falls within the publication period set in the SLR protocol.

Exclusion criteria

An article was excluded if:

1. it addresses only critical thinking without a clear relationship to critical reasoning;
2. it is not related to science education;
3. it is not related to the assessment or measurement of critical reasoning;
4. it is an editorial, review, proceedings paper, thesis, dissertation, or other non-article document when that type is not included in the search protocol;
5. it is a duplicate publication;
6. it does not provide sufficient information for data extraction.

Study Selection Process

The articles obtained from the search went through several selection stages. The first stage was the identification of all articles retrieved from the databases and search sources, followed by the removal of duplicate articles. The remaining articles were screened by title and abstract to identify their suitability to the focus of the study. Articles that met the criteria at this initial stage were then examined in full text to determine final eligibility.

The article selection process is reported using the PRISMA diagram (Figure 1), which comprises four main stages:

Identification → Screening → Eligibility → Included

The number of articles at each stage was recorded systematically so that the selection process can be replicated and reported transparently.

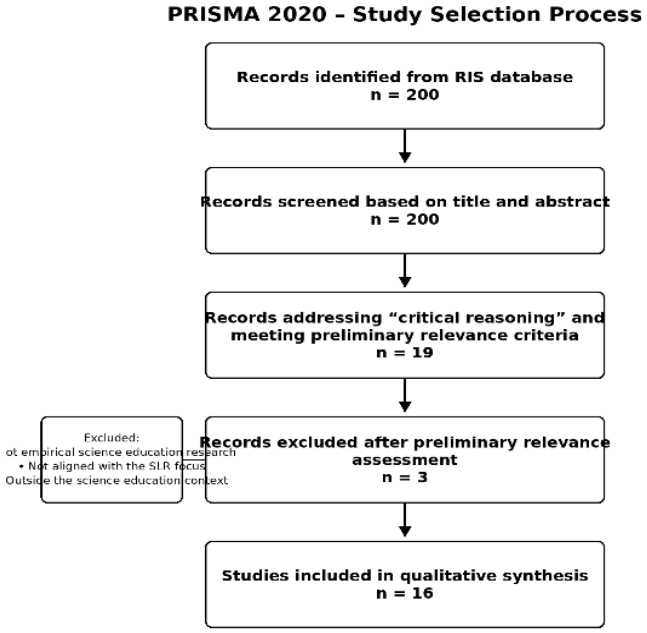

Figure 1. PRISMA 2020 flow diagram of the study selection process.

Data Extraction

Articles that met the inclusion criteria were analyzed using a data extraction sheet developed from the research questions. The information extracted included:

Table 1. Variables recorded in the data extraction sheet

Variable	Data recorded
Author & year	Authors and year of publication
Country	Country of the study
Education level	Elementary / junior high / senior high / university
Science domain	Science, biology, physics, etc.
Topic/content	Learning material used
Critical reasoning construct	Definition/construct of critical reasoning
CR indicators	Indicators/dimensions of critical reasoning
Assessment type	Test, essay, diagnostic, e-assessment, etc.
Instrument development	ADDIE, 4D, Rasch, etc.
Validity	Validation technique/results
Reliability	Reliability technique/results
Learning integration	Form of integration with learning
Local wisdom	Whether present and in what form
Main findings	Key findings
Research limitations	Limitations
Research gap	Research opportunities that remain open

Data Synthesis

The data were analyzed descriptively and thematically. The descriptive analysis was used to identify the distribution of studies by publication year, country, education level, science domain, learning material, and form of assessment. The thematic analysis was used to identify patterns in the conceptualization of critical reasoning, the indicators used, instrument characteristics, the integration of assessment with learning, and the utilization of local wisdom.

In addition to content analysis, the relationships among keywords and research themes were visualized using VOSviewer (van Eck & Waltman, 2010). The visualization was used as a supporting analysis to identify patterns of keyword relationships and the development of research themes, whereas the determination of the research gap remained based on reading and synthesizing the content of the articles.

Results and Discussion

Study Selection

The initial search yielded 200 articles obtained from an RIS file with a publication range of 2022–2026. All records were then examined by title and abstract, considering their suitability to the focus of the review, namely critical reasoning, assessment, science learning, and local wisdom.

At the initial screening stage, articles that explicitly discussed only critical thinking, without showing a conceptual or operational relationship to critical reasoning, were not prioritized for synthesis. Likewise, articles that discussed other forms of reasoning, such as scientific reasoning, clinical reasoning, moral reasoning, or mathematical reasoning, were not included as primary studies because their constructs differ from the focus of the review.

Based on the examination of titles and abstracts, a number of articles were found that explicitly used the term critical reasoning and were related to science education. Among them were studies on the development of assessment instruments, psychometric validation, diagnostic assessment, the integration of assessment with ecology learning, learning based on socioscientific issues, and learning based on local wisdom.

Thus, the selection process in this study did not merely consider the presence of the word reasoning but also examined whether critical reasoning was a construct relevant to the aims of the review. Articles that used only the term critical thinking were not used as the main basis of the synthesis.

Characteristics of the Identified Studies

The screening results show that critical reasoning research in science education has several main directions. First, studies focus on the development and validation of assessment instruments. Second, studies integrate critical reasoning into learning models or devices. Third, some studies use socioscientific or ecological contexts as environments for eliciting students' reasoning. Fourth, some studies have begun to connect critical reasoning with local wisdom.

The studies most relevant to the focus of this SLR are presented in Table 2.

Table 2. Candidate critical reasoning studies relevant to the review

Study	Research focus	Relevance to the SLR
Utaminingsih et al. (2024b)	Development of a critical reasoning instrument in science learning	Assessment + CR
Nuha et al. (2024)	Development of an e-module based on a three-dimensional thinking graph to improve critical reasoning	Learning device + CR
Asmi et al. (2026)	Project-based multimedia to improve critical reasoning of elementary school students	Science learning + CR
Aprilia et al. (2026)	Rasch psychometric validation of a critical reasoning assessment on virus material	Assessment + Biology + CR
Yokhebed et al. (2024)	Online socioscientific-issue-based flipped classroom to improve critical reasoning	CR + SSI
Ekawati et al. (2024)	Critical reasoning assessment instrument as a diagnostic assessment in physics learning	Assessment + CR
Arisandi et al. (2025)	Panca Pramana model for scientific literacy and critical reasoning	Local wisdom + Science + CR
Utaminingsih & Ellianawati (2025)	STEAM e-module on the human circulatory system and critical reasoning	Learning device + CR
Kurniawan et al. (2026)	Physics worksheet based on Mabbulo Sipeppa local wisdom	Local wisdom + CR
Utaminingsih et al. (2025)	Sustainable-education-oriented STEM e-module to improve critical reasoning	STEM + CR
Yokhebed et al. (2026)	Place-based socioscientific issues to improve critical reasoning of prospective science teachers	Place-based + CR
Setiowati et al. (2025)	Authentic e-assessment in ecology learning	Assessment + Ecology + CR
Utaminingsih et al. (2024a)	STEAM-based PRISMA e-module for critical reasoning	STEAM + CR
Syamsiah et al. (2026)	Deep learning approach and its effect on conceptual understanding and critical reasoning	Learning approach + CR
Nofiyanti et al. (2026)	Critical reasoning in reproductive system learning integrated with Al-Quranic values	Biology + contextual values + CR
Sandi & Ahmad (2025)	Heyzine-assisted e-book with the Learning Cycle, viewed from critical reasoning	Learning integration + CR

Source of Table 2 data: initial screening results of the RIS file.

Critical Reasoning Assessment Research

One of the clearest research patterns is the development of instruments specifically intended to measure critical reasoning. Ekawati et al. (2024) explicitly developed a critical reasoning skills assessment instrument as a diagnostic assessment in physics learning. This study shows that critical reasoning assessment has begun to be directed not only at producing ability scores but also at obtaining diagnostic information about students' reasoning abilities.

A similar pattern is seen in Aprilia et al. (2026), who conducted a psychometric validation using the Rasch model of a critical reasoning assessment on virus material in biology learning. Rasch analysis is widely used to examine the quality of measurement instruments, including item functioning and the fit of persons and items (Boone, 2016). The presence of this study shows that measurement quality, including validity and item characteristics, has become a concern in developing critical reasoning assessment.

These findings show that critical reasoning assessment research has developed in terms of instrument construction, validation, and psychometric analysis. However, research of this kind tends to focus on the quality of the instrument as a measurement tool. What still needs attention is how such assessment devices are placed systematically in the learning process, so that student activities can simultaneously generate reasoning evidence that can be assessed.

Integration of Critical Reasoning Assessment with Science Learning

The screening results also show a tendency to integrate critical reasoning with learning activities. One highly relevant study is Setiowati et al. (2025), which used authentic e-assessment in ecology learning through the STEAMRel-PBL approach. In that study, critical reasoning was assessed using an assessment rubric within the context of ecology learning.

This finding is important because it shows a shift from assessment as a separate measurement activity toward assessment that is placed within the learning environment, an orientation consistent with the long-standing argument that assessment evidence gathered during instruction can inform and improve learning (Black & Wiliam, 1998). However, based on the identified studies, the forms of integration remain diverse, ranging from authentic assessment and e-assessment to tests and learning devices used to improve critical reasoning.

Thus, one emerging research opportunity is the need for an assessment design that is developed from the outset as an integral part of learning, not merely as an instrument administered after the learning process has ended.

Critical Reasoning and Local Wisdom

An especially important finding for this study is that several studies connect critical reasoning with local wisdom. Kurniawan et al. (2026), for example, developed Physics Co-Curricular Worksheets based on Mabbulo Sipeppa local wisdom to support deep learning and the development of students' critical reasoning. This study shows that local wisdom can be used as part of a learning context directed at supporting the development of critical reasoning.

In addition, Arisandi et al. (2025) developed the Panca Pramana model, which connects scientific literacy and critical reasoning in elementary school students. This study indicates that elements of local wisdom can become part of science learning designs related to the development of reasoning ability. However, neither group of studies directly addresses the need that is the focus of the present study, namely the development of critical reasoning assessment devices that are systematically integrated with ecosystem learning and based on a specific local wisdom.

Critical Reasoning in Ecological Context

The ecological context also emerged in the screening results. Setiowati et al. (2025) used ecology and biodiversity learning with authentic e-assessment to examine critical reasoning. An ecological context offers students the opportunity to deal with phenomena that involve many cause-and-effect relationships and require the use of evidence to reach conclusions.

The presence of this study shows that ecology is a relevant context for critical reasoning assessment. However, research that combines the following four elements simultaneously:

critical reasoning + assessment + learning integration + local wisdom

still appears limited in the initial screening results.

Synthesis of the Research Gap

Based on the initial synthesis, critical reasoning research in science education can be grouped into several main directions. The synthesis of the screening results shows four main tendencies:

1. Instrument development — studies develop and validate critical reasoning instruments.
2. Learning integration — critical reasoning is developed through models, modules, worksheets, e-modules, or learning approaches.
3. Contextual/SSI learning — critical reasoning is placed in socioscientific issues and specific contexts.
4. Local wisdom — some studies have begun to connect critical reasoning with local wisdom.

However, these four tendencies have rarely come together in a single research design that develops a critical reasoning assessment device as an integral part of local-wisdom-based science learning.

Identified Research Gap

Based on the synthesis, the research gap can be formulated at three levels.

Gap 1 — Assessment gap

Studies have produced empirically validated critical reasoning instruments, but greater attention is still given to the quality of the instrument as a measurement tool than to how the instrument is used to generate reasoning evidence during the learning process.

Gap 2 — Integration gap

Studies have connected critical reasoning with various learning models and authentic assessments, but designs that systematically integrate learning activities, reasoning tasks, reasoning evidence, and assessment remain limited.

Gap 3 — Local wisdom gap

Research on local-wisdom-based critical reasoning has begun to emerge, but the use of local wisdom as an integral part of critical reasoning assessment devices, particularly in ecosystem learning, has rarely been studied.

Main gap

Thus, the most relevant gap for this study can be formulated as follows:

> *Although previous studies have developed critical reasoning assessments and have incorporated critical reasoning into contextual science learning and local-wisdom-based learning, limited research has focused on developing an assessment device that systematically integrates critical reasoning assessment with the learning process while utilizing local wisdom as an authentic context for ecosystem learning.*

Synthesis by Research Focus

The synthesis of the identified studies shows that critical reasoning research in science education can be grouped into several main focuses, namely the development of assessment instruments, the integration of critical reasoning in the learning process, the application of critical reasoning in ecological contexts, and the integration of critical reasoning with local wisdom.

1. *Development of Critical Reasoning Assessment Instruments*

A number of studies focus on developing and validating instruments to measure critical reasoning. Ekawati et al. (2024) developed a critical reasoning assessment instrument used as a diagnostic assessment in physics learning. Meanwhile, Aprilia et al. (2026) analyzed the characteristics of a critical reasoning instrument on virus material using the Rasch approach. These studies show that the development of critical reasoning assessment has received attention in terms of instrument construction, validity, reliability, and item characteristics.

These findings show that the need for instruments to measure critical reasoning has begun to be addressed through various development and validation approaches. However, some studies still position the instrument primarily as a tool for measuring students' ability, so its relationship with learning activities and with how reasoning evidence is formed during learning needs further examination.

2. *Integration of Critical Reasoning into the Learning Process*

Another group of studies integrates critical reasoning into various learning devices and activities, such as e-modules, e-books, worksheets, and particular learning models. The studies by Nuha et al. (2024) and Sandi and Ahmad (2025), for example, show that learning devices can be designed to support the development of students' critical reasoning.

These findings show that critical reasoning is positioned not only as an ability measured through tests but also as an ability developed through learning experiences. Nevertheless, developing learning devices that aim to improve critical reasoning differs from developing assessment devices that systematically integrate critical reasoning indicators into learning activities. This difference indicates room to develop assessment that is at the same time part of the learning process.

3. *Critical Reasoning in Ecological Contexts*

The ecological context is one of the relevant learning contexts for developing critical reasoning. Setiowati et al. (2025) integrated authentic e-assessment into ecology and biodiversity learning to examine students' critical reasoning. The use of an ecological context allows students to deal with phenomena involving interactions between biotic and abiotic components, environmental change, and various ecological problems that require the use of evidence and reasoning.

These findings show that ecology learning has potential as an authentic context for developing and assessing critical reasoning. However, studies that specifically develop critical reasoning assessment devices integrated with the whole of ecosystem learning activities remain limited.

4. *Local-Wisdom-Based Critical Reasoning*

Several studies have begun to connect critical reasoning with local wisdom in science learning. Kurniawan et al. (2026), for example, developed Physics Co-Curricular Worksheets based on Mabbulo Sipeppa local wisdom to support deep learning and critical reasoning. The study by Arisandi et al. (2025) also shows a relationship between local-wisdom-based approaches, science learning, and the development of critical reasoning.

These findings show that local wisdom has begun to be used as a source of context in learning that supports the development of critical reasoning. However, studies that integrate local wisdom directly into critical reasoning assessment devices are still relatively limited. Moreover, the integration of local wisdom with critical reasoning assessment in ecosystem learning has rarely been examined.

Overall Synthesis

Overall, previous research shows that critical reasoning assessment, the integration of critical reasoning into learning, ecological contexts, and local wisdom have received research attention separately and in several combinations. However, the integration of critical reasoning assessment, the learning process, ecosystem material, and local wisdom in a single assessment device has rarely been studied. This

condition indicates room for developing an assessment device that not only measures critical reasoning but is also integrated with ecosystem learning activities and uses local wisdom as an authentic context.

Keyword Co-occurrence Analysis Using VOSviewer

A keyword co-occurrence analysis was conducted using VOSviewer to visualize the relationships among themes in critical reasoning research in science education. The network visualization shows the relationships among keywords based on their occurrence and co-occurrence in the analyzed articles. The node size indicates the relative frequency of a keyword, whereas the lines connecting nodes indicate relationships between keywords. Different colors indicate the grouping of keywords into clusters based on network relationships.

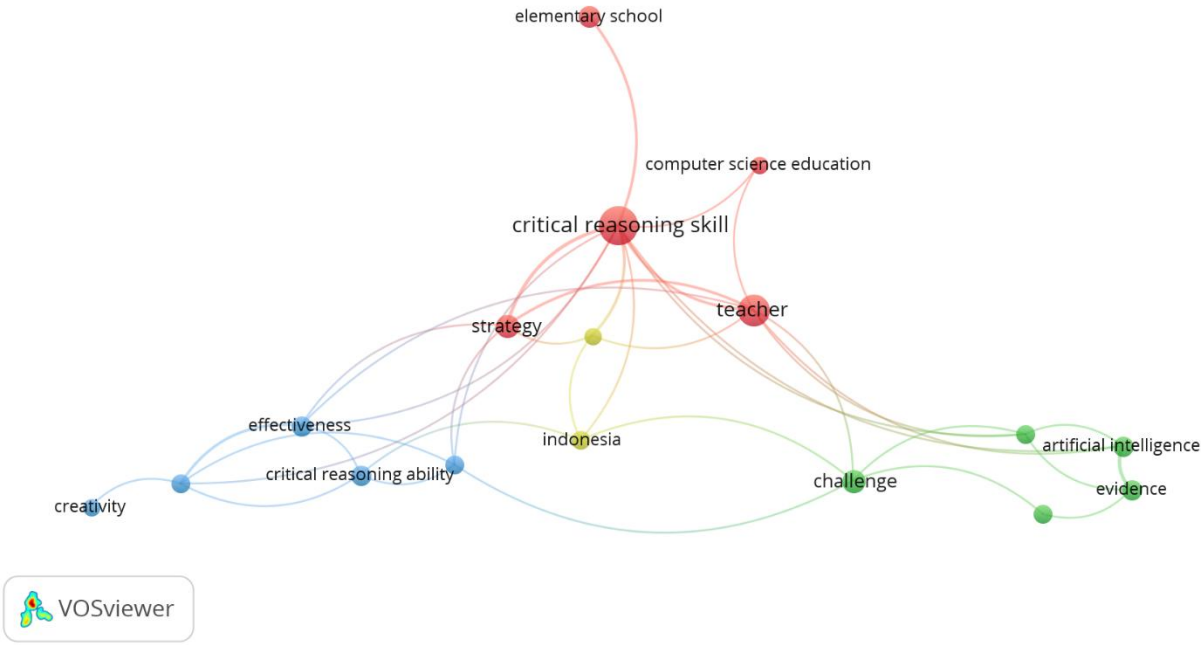

Figure 2. Network visualization of keyword co-occurrence in critical reasoning research.

Based on Figure 2, the keyword network shows four main theme groups marked in red, blue, green, and yellow. Critical reasoning skill appears as one of the most prominent nodes in the network and is connected to several other research themes. This position indicates that critical reasoning is one of the central themes linking various research foci in the dataset.

Red cluster

The red cluster is centered on the keyword critical reasoning skill and is connected to keywords such as teacher, strategy, computer science education, and elementary school. This pattern shows that critical reasoning research does not discuss students' ability only as an individual construct but also relates it to learning strategies, the role of teachers, education levels, and particular fields of education. The connection of critical reasoning skill with strategy and teacher indicates attention to how this ability is developed through the learning process.

Blue cluster

The blue cluster includes keywords such as critical reasoning ability, effectiveness, creativity, and students critical reasoning. This cluster shows a research tendency that focuses on students' critical reasoning ability and its relationship with learning effectiveness and other relevant abilities. The presence of critical reasoning ability as an important node indicates that research is also directed at measuring or evaluating students' reasoning ability.

Green cluster

The green cluster shows the keywords artificial intelligence, evidence, and challenge, which relate to themes in contemporary science education. The relationship between critical reasoning and evidence is important because the use of evidence is one of the relevant characteristics of scientific reasoning. Meanwhile, the appearance of artificial intelligence shows that some studies in the dataset have begun to link reasoning ability with technological developments and contemporary learning challenges.

Yellow cluster

The yellow cluster is connected to the keyword Indonesia and is located relatively close to the red and green clusters. This position indicates that the Indonesian research context is related to several main themes in the critical reasoning research network. This cluster also serves as one of the links between the theme of critical reasoning, learning strategies, and broader educational issues.

Interconnections between clusters

Beyond the characteristics of each cluster, the network pattern shows that critical reasoning skill is related to various theme groups. These relationships show that critical reasoning research has developed in several directions, from developing students' abilities, learning strategies, and the role of teachers to the use of evidence and educational technology. Thus, critical reasoning research is not an isolated theme but is connected to various aspects of science learning.

However, the network visualization also shows that local wisdom and ecosystem/mangrove contexts do not appear as main nodes in the visualized network. This finding indicates that the relationship between critical reasoning and the context of local wisdom has not become a dominant theme in the analyzed research network. Nevertheless, this finding should be understood as a bibliometric indication, not as evidence that research on local wisdom has never been conducted. The VOSviewer results need to be read together with the screening results and the content synthesis of the articles.

Thus, the VOSviewer analysis reinforces the literature synthesis, showing that critical reasoning research has developed in terms of ability, learning strategies, assessment, the use of evidence, and technology, whereas the relationship with local wisdom and ecosystem contexts has not appeared as a dominant theme in the research network. This condition supports the need for further analysis of the content of the articles to identify research opportunities that can be developed through critical reasoning assessment that is integrated with learning and uses local wisdom as an authentic context.

Development of Critical Reasoning Assessment

The synthesis shows that the development of critical reasoning assessment has become one of the research focuses in science education. Several studies have developed instruments specifically intended to identify and measure students' critical reasoning ability. The development includes constructing assessment items, validating the instrument, analyzing item characteristics, and using psychometric approaches to obtain information about instrument quality.

This development shows that critical reasoning is beginning to be positioned as a construct that can be operationalized through assessment devices. Thus, critical reasoning assessment functions not only to determine general learning achievement but can also be used to obtain information about students' ability to analyze information, use evidence, consider relationships among arguments, and make decisions based on accountable reasons.

Nevertheless, the synthesis shows that some studies still position assessment as a measurement instrument that is relatively separate from the learning process. This condition indicates the need for an assessment approach that not only produces critical reasoning scores but also generates reasoning evidence during learning activities. Such integration is important because reasoning ability can be observed not only in students' final responses but also in the process through which students identify problems, use information or evidence, connect concepts, and give reasons for a conclusion. This view is consistent with the conception of assessment as a process of reasoning from evidence, which requires coherence among a model of student cognition, the observations that elicit evidence, and the interpretation of that evidence (Pellegrino et al., 2001).

Integration of Critical Reasoning Assessment in Science Learning

The review shows that critical reasoning research has also developed through integration with various learning approaches, such as problem-based learning, socioscientific issues, worksheets, e-modules, and digital learning devices. These approaches give students the opportunity to deal with problems that require thinking and the use of reasons before reaching a decision.

Integrating critical reasoning with learning has important implications for assessment design. If assessment is given only at the end of learning, the information obtained tends to describe the final result of students' ability. In contrast, assessment integrated with learning allows teachers to obtain evidence of the development of reasoning ability while learning is under way.

Therefore, critical reasoning assessment devices should ideally not stand as components separate from learning devices. Reasoning indicators need to be translated into activities, questions, tasks, stimuli, rubrics, and assessment criteria that appear throughout the learning process. This approach allows assessment to function more authentically as part of learning and, at the same time, as a source of information about students' ability development.

This finding shows a difference between assessment of learning and assessment integrated into

learning. This difference is an important aspect in developing critical reasoning assessment devices.

Critical Reasoning in Ecosystem Learning

Ecosystem material has characteristics suited to developing critical reasoning because it involves complex relationships between biotic and abiotic components, interactions among living things, environmental change, and various ecological problems. These phenomena provide a context that enables students to use evidence, identify cause-and-effect relationships, compare different pieces of information, and give reasons for a problem.

The review shows that ecological contexts have been used in studies connecting science learning, authentic assessment, and critical reasoning. Using an ecological context offers the opportunity to present problems that are closer to real-life phenomena than questions oriented only toward concept mastery.

However, ecosystem contexts in previous studies have not been widely developed together with a local wisdom approach as a source of assessment stimuli. Yet ecosystem phenomena in students' surroundings can provide a more authentic context for building reasoning processes. Students do not merely deal with the ecosystem concept in the abstract but can use environmental phenomena as a basis to identify problems, analyze evidence, and argue based on real conditions.

Local Wisdom as an Authentic Context for Critical Reasoning Assessment

The synthesis shows that local wisdom has begun to be used in science learning to provide contexts that are close to students' lives. Several studies have even connected local wisdom with the development of critical reasoning. These findings show that local wisdom has potential not only as a source of cultural knowledge but also as a context that can present authentic problems in learning.

Using local wisdom in critical reasoning assessment can offer a different experience from using a general context. Local phenomena can provide information, data, problems, and evidence that allow students to carry out reasoning processes based on situations observable in everyday life. Studies of local ecological knowledge, such as the local wisdom of mangrove utilization in coastal communities in West Kalimantan (Eralita et al., 2025), also show that community practices related to mangroves can serve as contextual resources for science education.

In science education, local wisdom can also function as a bridge between scientific knowledge and students' experience. Students can compare local knowledge or practices with scientific concepts, evaluate evidence, identify cause-and-effect relationships, and give reasons for an environmental problem. This process has been discussed in terms of helping students cross the boundary between their everyday cultural worlds and the world of science (Aikenhead & Jegede, 1999), and it is relevant to the development of critical reasoning.

Although research on critical reasoning and local wisdom has begun to develop, the synthesis shows that the integration of the two in an **assessment device** that is simultaneously connected to ecosystem learning activities remains limited. Thus, local wisdom has the opportunity to be developed not only as a learning context but also as part of the design of assessment stimuli and activities.

Research Gap and Implications for Assessment Development

Based on the overall synthesis, previous research has contributed to several aspects, namely the development of critical reasoning instruments, the integration of critical reasoning into science learning, the use of ecological contexts, and the utilization of local wisdom in learning. However, these four aspects have rarely been found in a single, systematically integrated assessment device design.

The identified research gap does not lie in the absence of research on critical reasoning or local wisdom but in the limited integration of these elements in a single learning assessment device. In particular, few studies have developed assessment devices that connect critical reasoning indicators with ecosystem learning activities and use local wisdom as an authentic context for generating students' reasoning evidence.

These findings imply that the future development of assessment devices needs to consider three main characteristics. First, the assessment needs to have clear and operational critical reasoning indicators. Second, assessment tasks need to be integrated with learning activities so that reasoning evidence can be obtained during the learning process. Third, assessment stimuli and problems need to use authentic contexts relevant to students' environment.

In this context, the local wisdom of the Lantebung Mangrove Forest area in Makassar has potential to be used as an authentic context in ecosystem learning. Mangrove phenomena can present ecological problems that enable students to analyze relationships among ecosystem components, use evidence, evaluate information, consider various possibilities, and draw conclusions based on logical reasons.

Thus, the results of this SLR provide a conceptual basis for developing a critical reasoning assessment device integrated with local-wisdom-based ecosystem learning. Such development is not intended merely to produce a new measurement instrument but to produce a device that connects the critical reasoning construct,

learning activities, the ecosystem context, local wisdom, and assessment evidence in a unified learning design.

Limitations

This review has several limitations. First, the analysis was based on studies identified within the selected literature database and search strategy; therefore, relevant studies that were not indexed in the selected database may not have been included. Second, the analysis focused specifically on the term critical reasoning and did not treat critical thinking as an equivalent construct. This distinction was maintained to ensure conceptual consistency with the focus of the review.

Third, the VOSviewer analysis was used as a complementary bibliometric analysis rather than as the sole basis for determining the research gap. The identification of the research gap was based on the combined interpretation of keyword relationships, study characteristics, and thematic synthesis of the selected literature. Future reviews may expand the database coverage, publication period, and search strategy to obtain a broader representation of research on critical reasoning assessment.

Implications of the Review

The results of this review have implications for both research and science education practice. From a research perspective, future studies can focus on developing assessment devices that connect critical reasoning indicators with authentic learning activities rather than treating assessment solely as a final measurement instrument.

From an instructional perspective, ecosystem contexts and local wisdom can be utilized to construct authentic problems, stimuli, evidence, and assessment tasks that require students to demonstrate reasoning processes. Such an approach may strengthen the connection between scientific concepts, students' environmental experiences, and the development of higher-level reasoning abilities.

For assessment development, the findings suggest that an effective device should consider the alignment among learning objectives, critical reasoning indicators, learning activities, contextual stimuli, student responses, and scoring criteria. This alignment is important to ensure that the evidence collected through assessment genuinely represents students' critical reasoning rather than merely their ability to recall scientific information.

Conclusion

This systematic literature review examined the development of critical reasoning research in science education, particularly its relationship with assessment, learning integration, ecosystem contexts, and local wisdom. The synthesis indicates that previous studies have addressed critical reasoning through the development and validation of assessment instruments, the integration of reasoning activities into science learning, and the use of authentic scientific and ecological contexts.

The findings further indicate that local wisdom has increasingly been incorporated into science learning and has potential to provide meaningful contexts for developing critical reasoning. However, the integration of critical reasoning assessment, learning activities, ecosystem content, and local wisdom within a single assessment device remains relatively limited. Existing research tends to emphasize these components separately or combine only some of them.

Therefore, the main research gap identified in this review concerns the development of a learning-integrated critical reasoning assessment device that uses ecosystem phenomena and local wisdom as an authentic context for eliciting and evaluating students' reasoning processes. Such an assessment approach has the potential to provide more meaningful evidence of students' reasoning than assessment that is separated from the learning process.

The findings provide a conceptual basis for further development of critical reasoning assessment in science education, particularly through authentic ecosystem contexts that are closely connected to students' local environments and experiences.

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Author Contributions

Astina Hasrida was responsible for writing the abstract and the introduction. Ramlawati was responsible for developing the method. M. Agus Martawijaya was responsible for writing the discussion and the conclusion. All authors have read and approved the final version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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