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ASSESSMENT OF MATHEMATICS CRITICAL THINKING: A SYSTEMATIC REVIEW

Silky Achilla[1], Masrukan[2], Iqbal Kharisudin[3]
[1,2,3]Universitas Negeri Semarang, Semarang, Indonesia
e-mail: achillasilky@students.unnes.ac.id

Abstract

This study presents a systematic review of research on the assessment of mathematical critical thinking published between 2018 and 2025. The review was conducted using the PRISMA method to obtain a comprehensive understanding of research characteristics, assessment designs, the dimensions of critical thinking evaluated, and the mathematical content used across various studies. The findings indicate a significant increase in scholarly attention toward mathematical critical thinking, reflected in the growing number of publications across different educational levels and geographic regions, particularly in Asia. The methodological diversity found in the studies, including experimental, quasi-experimental, qualitative, survey-based, and research and development approaches demonstrates that assessing critical thinking requires flexible and context-sensitive strategies. Further analysis reveals that the critical thinking skills evaluated in the studies include analysis, evaluation, interpretation, inference, generalization, mathematical modeling, and argument construction. The mathematical content assessed is similarly varied, ranging from algebra, geometry, statistics, calculus, and discrete mathematics to modeling and complex analysis. These findings show that mathematical critical thinking is a multidimensional competency relevant to all areas of mathematics. Overall, the results highlight the need for developing authentic, valid, and curriculum-aligned assessment instruments to strengthen students' mathematical reasoning and support the demands of 21st century learning.

Keywords: assessment, critical thinking mathematics, systematic review

Abstrak

Penelitian ini menyajikan tinjauan sistematis mengenai asesmen kemampuan berpikir kritis matematis yang dipublikasikan dalam rentang tahun 2018 hingga 2025. Kajian dilakukan menggunakan metode PRISMA untuk memperoleh gambaran komprehensif tentang karakteristik penelitian, desain asesmen, keterampilan berpikir kritis yang diukur, serta cakupan konten matematika yang digunakan dalam berbagai studi. Hasil telaah menunjukkan bahwa perhatian terhadap kemampuan berpikir kritis matematis mengalami peningkatan signifikan, ditandai dengan bertambahnya jumlah publikasi pada berbagai jenjang pendidikan dan wilayah geografis, khususnya di Asia. Variasi metodologis yang digunakan, meliputi penelitian eksperimen, quasi-eksperimen, kualitatif, survei, serta penelitian dan pengembangan, menunjukkan bahwa asesmen berpikir kritis menuntut pendekatan yang fleksibel dan kontekstual. Analisis lebih lanjut memperlihatkan bahwa keterampilan berpikir kritis yang dinilai dalam penelitian mencakup analisis, evaluasi, interpretasi, inferensi, generalisasi, pemodelan matematis, serta konstruksi argumen. Konten matematika yang digunakan pun beragam, mulai dari aljabar, geometri, statistika, kalkulus, matematika diskrit, hingga pemodelan dan analisis kompleks. Temuan ini menunjukkan bahwa kemampuan berpikir kritis merupakan kompetensi multidimensional yang relevan dalam seluruh bidang kajian matematika. Secara keseluruhan, hasil penelitian menegaskan perlunya pengembangan instrumen asesmen yang autentik, valid, dan selaras dengan tuntutan kurikulum modern untuk mendukung penguatan penalaran matematis dan kompetensi abad ke-21.

Kata kunci: penilaian, berpikir kritis matematis, tinjauan sistematis

INTRODUCTION

Critical thinking is conceptually defined as a skilled cognitive process involving the active and reflective analysis, evaluation, and synthesis of information to make reasoned decisions (Emilo et al., 2025). In the mathematics domain, mathematical critical thinking manifests as

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the ability to analyze complex problems, evaluate the validity of various solution approaches, construct logical arguments based on mathematical evidence, and reflect on and adapt the thinking strategies used (Baidawi et al., 2023). This concept fosters higher-order thinking skills that go beyond routine computation and lead to conceptual understanding and independent reasoning (Utami et al., 2022).

The importance of assessing mathematical critical thinking is crucial for documenting student development and demonstrating the effectiveness of innovative pedagogical approaches (Azmi et al., 2025). Authentic, performance-based assessments serve as diagnostic tools to identify student achievement levels and provide teachers with a roadmap for designing more challenging and meaningful learning. Without reliable and valid assessment instruments, efforts to integrate and improve critical thinking in the mathematics curriculum become less focused and their impact is difficult to measure (Ridwan et al., 2022).

One of the causes of weak critical thinking skills is mathematics assessments, which still predominantly focus on memorization and procedural solutions. A recent NCTM (2024) report emphasized that traditional assessments, such as high stakes multiple-choice tests, prevent students from developing in-depth reasoning and problem solving skills. This difficulty is also experienced by teachers and teacher candidates, who often lack adequate training in designing assessments that tap into students' thinking processes (Koh & Chapman, 2019).

Furthermore, students' metacognitive aspects such as the ability to monitor and evaluate their thinking strategies also play a crucial role. Various studies have shown that metacognitive weaknesses cause students to struggle to understand mathematical concepts, lack confidence, and hesitate to express ideas (Moodley et al., 2015; Syaiful, 2019).

At the same time, recent literature points to methodological challenges in designing assessments to measure higher-order mathematical competencies. Nortvedt & Buchholtz (2018) emphasize that most assessments still fail to capture the complexity of students' thinking processes. Similarly, Drijvers et al. (2019) show that mathematics assessment practices are often not aligned with modern curriculum goals that demand reasoning, modeling, and non-routine problem solving.

Given these conditions, a systematic review of critical thinking assessment in mathematics is crucial. This study aims to provide an up-to-date overview of how the

mathematics critical thinking assessment was developed, what types of assessments are used, what critical thinking skills are assessed, and how the assessment process is conducted. This review is expected to contribute to the development of higher-quality assessment designs, improve teacher competency in conducting assessments, and help determine the direction of future research in assessing higher order thinking skills in mathematics. This raises several sub-questions:

- How is research on the assessment of higher-order mathematical thinking skills characterized by year of publication, geographic distribution, educational level, research design, and mathematical content area?
- What are the research focuses in the current literature on assessment? What are the critical thinking skills in mathematics? Specifically, what critical thinking skills are assessed and how are they assessed?

Literature Review

Mathematical Critical Thinking

Mathematical Critical Thinking (MCT) has evolved into a construct distinct from general critical thinking due to its context and formal object. MCT is conceptually understood as a higher-order cognitive process involving reflective analysis, logical evaluation, and synthesis of arguments in the mathematical domain (University, 2019). *Essentially, MCT is a combination of thinking skills such as analysis and evaluation, with thinking dispositions such as intellectual curiosity, a desire for clarification, and objectivity in assessing evidence* (Worthington, 2019; Emilo et al., 2025). *Thus, MCT is not a final product, but rather an intellectual habit (habit of mind) developed through systematic practice in solving non-routine and complex mathematical problems* (Syafril et al., 2020).

Mathematical critical thinking has developed since the critical thinking movement era and has been explored by various experts such as Ennis (1985), Facione (1990), Davies (2006), Moore (2013). *In general, critical thinking is understood as the ability to assess information, evaluate arguments, and make logical and reflective decisions.* Siswono (2010) *defines critical thinking as a thought process that examines, connects, and evaluates various aspects of a situation or problem. The literature shows five main themes that consistently emerge as*

indicators of critical thinking skills: interpreting, analyzing, evaluating, explaining, and creating (Facione, 1990; Moore 2013).

Analyzing

Analyzing is the ability to decipher the structure of an argument, identify relationships between concepts, and make both inductive and deductive inferences (Lai, 2011; Facione, 2011). In the context of mathematics, analyzing occurs when students develop problem-solving strategies, consider assumptions, or evaluate solution steps.

Evaluating

Evaluating involves assessing the quality of decisions, strategies, or evidence used to solve problems (Facione & Facione, 2008; Alsaleh, 2020). Sub-themes include assessing claims, making judgments based on specific criteria, and verifying supporting evidence (Lipman, 1988; Lai, 2011).

Explaining

Explaining involves the ability to provide reasons, explanations, or justifications for the thinking used (Facione, 1990; Halpern, 2014). In mathematics, this ability is evident when students must explain the steps for solving a problem, the reasons for choosing a strategy, or the interpretation of calculation results.

Creating

Creating relates to the ability to generate new ideas, different strategies, or non-algorithmic solutions to a problem. This often occurs in the context of open-ended and authentic problems that allow for multiple approaches to solving (Resnick, 1987; Siswono, 2010). Sub-skills such as *self-regulation* are also included in this aspect, where students reflect on their thinking processes before making a final decision (Facione, 2011).

Assessment Mathematical in Education

Assessment in education encompasses a variety of tasks, instruments, and strategies used to obtain information about students' learning processes and achievements. In the context of assessing mathematical critical thinking skills, these assessments are classified based on the type of task, such as multiple-choice, constructive response, or performance tasks, and their intended use, whether for formative or summative purposes (Made & Mertasari, 2023).

To gather authentic evidence about how students think, the literature recommends authentic assessment as a more comprehensive approach to assessing critical thinking skills. Koh (2017) and Wiggins (1989) explain that authentic assessment involves open-ended tasks, non-routine problems, real-world contexts, and high intellectual demands, allowing students to demonstrate more complex thinking processes. Performance standards in authentic assessments are usually expressed in the form of rubrics, which can be used in both formative and summative assessments. Authentic assessment forms such as projects, portfolios, written reports, journals, and oral presentations are considered capable of encouraging students to develop reasoning, argument evaluation, and reflective skills, which are key aspects of mathematical critical thinking (Burkhardt, 2007).

METHODS

An in-depth review of relevant literature on critical thinking assessment in mathematics education was conducted. This study was compiled using *the Preferred Reporting Items for Systematic Reviews and Meta-Analyses* (PRISMA) method (Page et al., 2021). Figure 1 illustrates the article selection process. The authors first identified studies published between 2018 and 2023 that aligned with the research objectives. To ensure objectivity and avoid bias toward prominent or highly cited empirical studies, we conducted keyword searches in several databases, such as Semantic Scholar, PubMed, Crossref, and Google Scholar. The keywords and phrases used were: “mathematics”, and “critical thinking”, or “assessment”, or “assessment of critical thinking”, or “critical thinking mathematics”, or “assessment of critical thinking mathematics”. The initial search yielded 20,272 results. After removing 8,491 duplicates, 11,781 articles remained. The authors then screened the titles and abstracts of all 11,781 articles. During this stage, 5,846 articles were excluded for not meeting the relevant criteria for the focus of this study, resulting in 5,935 articles for further review. The authors then read the full text of all 5,911 articles to determine their eligibility. Studies that did not meet the inclusion criteria were excluded. The final inclusion stage yielded 24 articles. The authors collaboratively established the inclusion and exclusion criteria, as well as the review procedures. These criteria are summarized in Table 1.

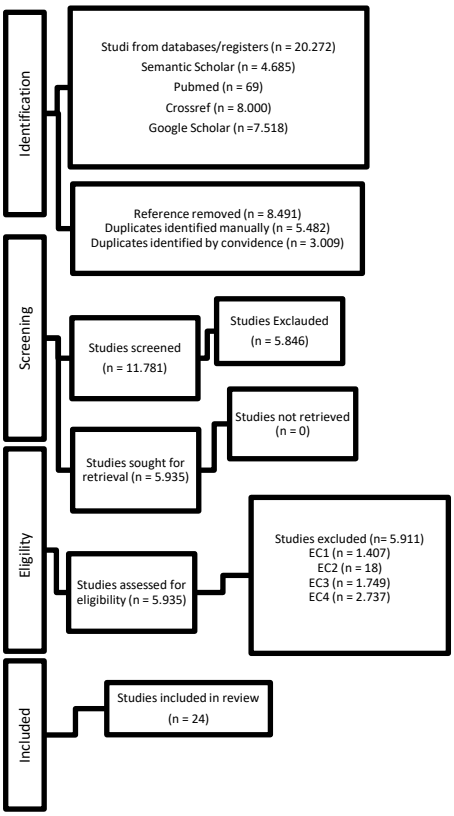

Figure 1. Illustrates the article selection process

Inclusion criteria (IC)	Exclusion criteria (EC)
1. Research focused on assessing mathematical critical thinking 2. Studies at all levels of mathematics education 3. Empirical studies 4. Studies published in English 5. Studies published in mathematics education and assessment journals	1. Assessments that do not focus on critical mathematical thinking 2. Studies on mathematics but at a broad educational level or school level 3. Theoretical papers, books, book chapters, and commentaries 4. Studies published in languages other than English 5. Studies published outside of mathematics education and assessment journals

Table 1. These criteria are summarized

RESULTS AND DISCUSSION

RESULTS

Study Characteristics of the Papers (Research Sub-Question 1)

Distribution of Research by Year of Publication

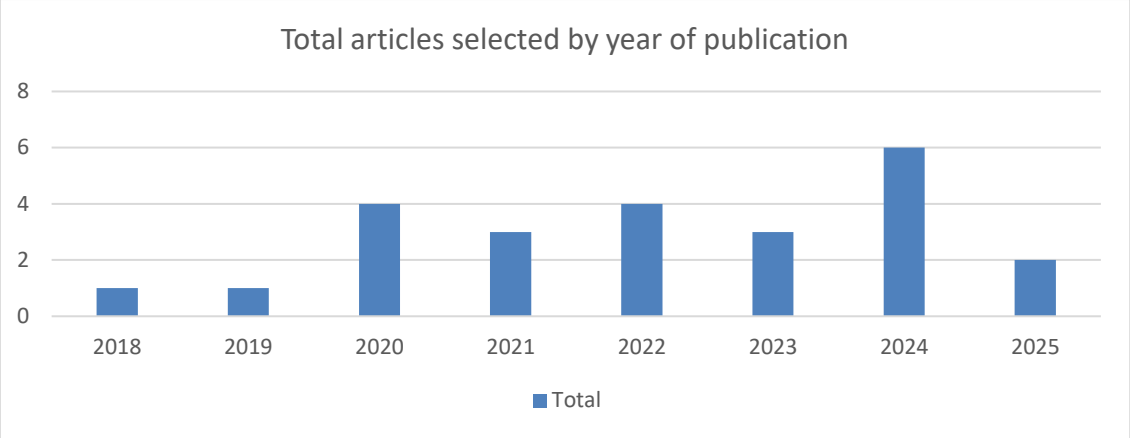

Figure 2. Total articles selected by year of publication

An overall analysis of publications shows that research on the assessment of mathematical critical thinking skills experienced a steady increase in the time span from 2018 to 2025. Monteleone et al. (2018) which became an important foundation in research on mathematical reasoning based assessment instruments in 2018. The next research appeared in 2019 through the work of Rogovaya et al. (2019), followed by several studies in 2020 that were quite dominant, such as Erdoğan (2020); Priatna et al. (2020); Zafarghandi et al. (2020) ; and Setyawan et al. (2020). 2021 was filled with publications from Insorio & Librada (2021); Asigigan & Samur (2021); and Güner & Gökçe (2021). In 2022, there was an increase in research diversity through the work of (Dailo & Dailo, 2022); Benedicto & Andrade (2022); Ismail et al. (2022); and (Syaiful et al., 2022). 2023 presented a diversity of study contexts through research by Fernando et al. (2023); Barana et al. (2023); and Bai et al. (2023). The peak of research growth was seen in 2024, indicated by the large number of publications, including (Syahri et al., 2024); (Ramadhan et al., 2024); (Sosa-gutierrez et al., 2024); (Kanwal et al., 2024); (Jamil et al., 2024); and (Ariza et al., 2024). The most recent publications are from (Syaiful et al., 2025)and (Garcia & Cruz, 2025). Overall, this distribution indicates that research on the assessment of mathematical critical thinking has continued to grow and received widespread attention over the past decade.

Distribution of Studies by Continent

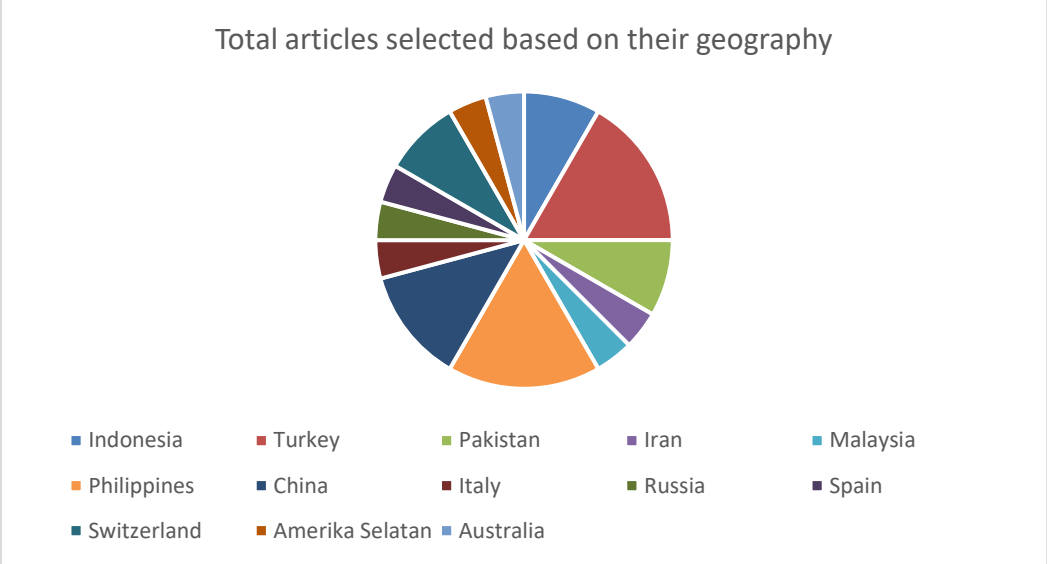

Figure 3. Total articles selected based on their geography

The geographic distribution of research shows that the topic of assessing mathematical critical thinking skills is a global concern. The Asian continent dominates the number of publications, with contributions from Indonesia through research by Syahri et al. (2024) and Setyawan et al. (2020). Other countries in Asia also play a role, including Turkey through research by (Erdoğan, 2020); (Priatna et al., 2020); Asigigan & Samur (2021); and Güner & Gökçe (2021). Pakistan through research (Kanwal et al., 2024); and Jamil et al. (2024). Iran through research by Zafarghandi et al. (2020). Malaysia through research by Ismail et al. (2022). The Philippines through research by Garcia & Cruz (2025); Dailo & Dailo (2022); Insorio & Librada (2021); and Benedicto & Andrade (2022). China through research by Fernando et al. (2023); Bai et al. (2023); and Ramadhan et al. (2024).

The European continent is attended by research from Italy by Barana et al. (2023), Russia through research by Rogovaya et al. (2019), and Spain through research by Ariza et al. (2024), as well as Switzerland through research by Syaiful et al. (2025); and Syaiful et al. (2022). Publications from South America appear in research by Sosa-gutierrez et al. (2024), while Australia contributes through research by Monteleone et al. (2018). This distribution shows that the focus on assessing critical thinking skills is not limited to one particular region, but rather reflects a transcontinental academic phenomenon.

Distribution of Studies by Education Level

Studies of educational levels show that research covers all levels of education. At the early childhood education (PAUD), elementary, and secondary school levels, research by Erdoğan (2020) ; Priatna et al. (2020) ; Zafarghandi et al. (2020) ; Garcia & Cruz (2025) ; Ramadhan et al. (2024) ; Dailo & Dailo (2022) ; Monteleone et al. (2018) ; Kanwal et al. (2024) ; Asigigan & Samur (2021) ; Jamil et al. (2024) ; Güner & Gökçe (2021) : Ismail et al. (2022) ; and Bai et al. (2023) highlight critical thinking skills in the context of basic mathematics learning. Studies at the high school level, such as Insorio & Librada (2021) ; Jamil et al. (2024) ; Güner & Gökçe (2021) ; and Ismail et al. (2022) , focuses on more complex reasoning and problem-solving skills. Higher education is one of the most researched domains, as seen in the publications of Syaiful et al. (2025) ; Syaiful et al. (2022) ; Ariza et al. (2024) ; Benedicto & Andrade (2022) ; Rogovaya et al. (2019) ; Sosa-gutierrez et al. (2024) ; Barana et al. (2023) ; Setyawan et al. (2020) ; Fernando et al. (2023) ; and Syahri et al. (2024) .

Distribution of Studies Based on Research Design

The research designs used in these studies are quite diverse. The research and development (R&D) approach was widely used by Priatna et al. (2020); Setyawan et al. (2020); and Ramadhan et al. (2024) to design instruments, learning modules, or critical thinking skills assessment tools. Experimental or quasi-experimental approaches were used by Dailo & Dailo (2022); Kanwal et al. (2024); Benedicto & Andrade (2022); Syaiful et al. (2022); Syaiful et al. (2025) to test the effectiveness of certain learning models in improving critical thinking skills.

Qualitative research, such as the work of Zafarghandi et al. (2020); Garcia & Cruz (2025); Fernando et al. (2023); Barana et al. (2023); Jamil et al. (2024); and Ariza et al. (2024), and quantitative research by Rogovaya et al. (2019); Güner & Gökçe (2021); and Ismail et al. (2022) provide an in-depth understanding of students' thinking processes. Several other studies, such as Syahri et al. (2024); Erdoğan (2020); Sosa-gutierrez et al. (2024); Monteleone et al. (2018); Insorio & Librada (2021); Asigigan & Samur (2021) used a survey or mixed-method approach to obtain a comprehensive picture of students' perceptions, abilities, and experiences in mathematics learning. This design variation demonstrates that assessing mathematical critical thinking skills requires a flexible and contextual methodological approach.

Distribution of Studies Based on Mathematics Field of Study

The fields of mathematics studied in the journal collection are quite diverse, ranging from differential equations (Syahri et al., 2024), general mathematics (Erdoğan, 2020), STEAM (Priatna et al., 2020), engineering mathematics (Fernando et al., 2023), geometry (Ramadhan et al., 2024), analysis and complex numbers (Setyawan et al., 2020), combinatorics (Barana et al., 2023), algebraic thinking (Monteleone et al., 2018), basic mathematics (Kanwal et al., 2024), statistics and probability (Insorio & Librada, 2021), mathematics anxiety (Güner & Gökçe, 2021), HOTS (Ismail et al., 2022), graphic interpretation and scientific argumentation (Ariza et al., 2024), advanced mathematics (Syaiful et al., 2022), and basic calculus (Syaiful et al., 2025). This distribution shows that critical thinking skills can be assessed through various mathematical topics, both in the basic conceptual realm and advanced analysis.

Research Focus (Research Sub-Question 2)

The research focus in the articles shows a clear trend, namely on instrument development, measuring critical thinking skills, and assessing the effectiveness of learning models. The development of learning tools and assessment instruments is the main focus of the research by (Syahri et al., 2024), Erdoğan (2020), and Zafarghandi et al. (2020). Fernando et al. (2023), Ramadhan et al. (2024), Setyawan et al. (2020), Sosa-gutierrez et al. (2024), Dailo & Dailo (2022), (Monteleone et al., 2018), (Kanwal et al., 2024), (Insorio & Librada, 2021), (Jamil et al., 2024), (Güner & Gökçe, 2021), (Ismail et al., 2022), (Ariza et al., 2024). Research (Barana et al., 2023) and (Garcia & Cruz, 2025) shows how technology, including artificial intelligence, can be used as a means to analyze students' mathematical reasoning abilities.

Research assessing the effectiveness of mathematical learning models was conducted by (Priatna et al., 2020), Rogovaya et al. (2019), Asigigan & Samur (2021), Benedicto & Andrade (2022), Bai et al. (2023), and Kanwal et al. (2024). With a focus on PBL, STEM education, and MLA. At the higher education level, pedagogical approaches such as APOS and M-APOS were examined in research by Syaiful et al. (2022) and (Syaiful et al., 2025). This pattern indicates that research on critical thinking assessment aims not only to assess students but also to develop learning strategies capable of fostering these competencies.

Mathematical Critical Thinking Skills

A review of all articles shows that mathematical critical thinking skills measured in various studies can be grouped into several main dimensions, namely analysis, evaluation, interpretation, inference, deduction, generalization, mathematical modeling, and argument construction. All articles in the dataset contribute to one or more of these dimensions. Analytical skills are the most frequently measured dimension, as in the studies of Erdoğan (2020), Priatna et al. (2020), Benedicto & Andrade (2022), Rogovaya et al. (2019), Insorio & Librada (2021), Ariza et al. (2024), Güner & Gökçe (2021), and Ismail et al. (2022). Evaluation skills appear strong in the studies of Zafarghandi et al. (2020). and Garcia & Cruz (2025), which assess students' ability to analyze the accuracy of mathematical solutions and arguments. The interpretation dimension also appears in the studies of Syahri et al. (2024), (Dailo & Dailo, 2022), and (Sosa-gutierrez et al., 2024), which assess students' ability to understand the context of the problem and the meaning of mathematical symbols.

Inference and deduction skills have been extensively analyzed in advanced research, such as by Bai et al. (2023), (Setyawan et al., 2020), and (Syaiful et al., 2025), which emphasize the ability to draw logical conclusions based on mathematical evidence. Meanwhile, generalization skills appear dominant in (Kanwal et al., 2024) and (Setyawan et al., 2020), especially in the context of STEM-based learning and non-routine problem solving.

The dimensions of mathematical modeling were analyzed in the studies (Fernando et al., 2023), (Ramadhan et al., 2024), and (Barana et al., 2023), which linked critical thinking skills to the process of building mathematical models of real situations. The ability to construct and reconstruct mathematical arguments was seen in the studies of (Syaiful et al., 2022), (Asigigan & Samur, 2021), and (Monteleone et al., 2018), which assessed the ability of students to construct logical and accountable mathematical reasoning. Meanwhile, the study of (Jamil et al., 2024)was more directed at *problem solving* than *critical thinking*. Abilities involving in-depth analysis, understanding context, drawing logical conclusions, evaluating arguments, and mathematical modeling in various fields of study are essential competencies in modern mathematics learning.

DISCUSSION

A synthesis of all articles shows significant developments in research on the assessment of mathematical critical thinking skills between 2018 and 2025. The increasing number of studies each year indicates that the issue of evaluating higher-order thinking skills in

mathematics is receiving increasing academic attention. Various published studies, such as Syahri et al. (2024), (Erdoğan, 2020), Priatna et al. (2020), (Zafarghandi et al., 2020), and (Garcia & Cruz, 2025) shows that this topic is part of a cross-disciplinary and cross-national scientific discourse.

The distribution of studies by continent shows a dominance of Asia, especially Indonesia, Turkey, Pakistan, Malaysia, the Philippines, and China. Publication of articles such as (Barana et al., 2023), (Sosa-gutierrez et al., 2024), (Fernando et al., 2023), (Monteleone et al., 2018), shows that research outside Asia is also growing, although the number is not as large as in the Asian region. Asia's dominance can be attributed to curriculum policies that emphasize strengthening numeracy literacy and higher-order reasoning. Meanwhile, in terms of educational level, research published by researchers (Kanwal et al., 2024), Syaiful et al. (2022), Syaiful et al. (2025), (Ismail et al., 2022) Research shows that critical mathematical thinking skills are seen as relevant at all levels of education. At the elementary and secondary levels, research focuses more on developing basic analytical skills; while at the higher education level, studies emphasize abstract thinking skills, mathematical modeling, and formal argumentation.

The diversity of research designs used indicates that assessing critical thinking skills requires a variety of methodological approaches. Studies using experimental designs by researchers (Jamil et al., 2024) and (Syaiful et al., 2025) demonstrate the effectiveness of certain learning models in improving critical thinking skills. Meanwhile, research with R&D designs such as those by Syahri et al. (2024) and Ramadhan et al. (2024) emphasizes the importance of construct validity and indicator clarity in developing assessment instruments. From a mathematics perspective, studies include algebra, geometry, calculus, discrete mathematics, modeling, and complex analysis. Researchers such as Benedicto & Andrade (2022), (Bai et al., 2023), and Barana et al. (2023) show that critical thinking assessment can be widely applied to various mathematics topics.

The critical thinking skills studied included analysis, interpretation, inference, evaluation, generalization, and the construction of mathematical arguments. Researchers (Sosa-gutierrez et al., 2024), (Zafarghandi et al., 2020), and (Priatna et al., 2020)emphasized that critical thinking is a combination of the ability to process information and the ability to assess the validity of mathematical arguments. These findings align with global assessment

trends moving toward the use of authentic tasks, analytical rubrics, and technology as assessment tools. Thus, all studies in the article demonstrate that mathematical critical thinking assessment is evolving toward a more comprehensive, contextual, and adaptive direction to developments in educational technology.

CONCLUSION

Based on a comprehensive review of all published articles, it can be concluded that research on assessing mathematical critical thinking skills has shown significant and relevant developments over the past decade. Various published studies confirm that strengthening critical thinking skills is a crucial priority in global mathematics learning.

Studies across continents and educational levels demonstrate that critical thinking skills are viewed as a fundamental competency that must be developed from elementary school through university. The diversity of methodological approaches, including experimental, quasi-experimental, qualitative, survey, and R&D research, demonstrates that critical thinking assessment requires instrument triangulation to capture the depth of students' cognitive abilities.

The critical thinking skills studied encompass various components such as analysis, inference, evaluation, interpretation, generalization, and mathematical argument construction. The published articles indicate that these skills are multidimensional constructs closely related to mathematical structures and how students understand and validate mathematical information.

Overall, the analyzed research underscores the importance of developing valid, reliable, and contextual assessment instruments, as well as the need to integrate critical thinking assessments into the mathematics learning process. These findings provide a solid foundation for developing learning policies and curricula that are more responsive to the challenges of modern mathematics education, particularly in addressing the demands of 21st-century competencies.

The results of this synthesis indicate that critical thinking assessment in mathematics learning plays a highly strategic role in improving the quality of learning processes and outcomes. Practically, the research findings have direct implications for teachers, lecturers, and instrument developers. Teachers and lecturers need to use assessments that require analysis, evaluation, and argumentation, so that students are better trained to think logically

and reflectively. Instrument developers are also encouraged to design assessment tools that are authentic, contextual, and aligned with critical thinking skill indicators so that they can be used at various levels of education. Theoretically, the results of this study enrich our understanding of critical thinking measurement frameworks and demonstrate that diverse assessment models, ranging from essay tests and problem-based assessments to technology-assisted assessments, have a strong theoretical basis for evaluating students' thinking processes.

However, this study still has several limitations. The number of journals analyzed was limited by available sources, so it does not cover the full range of research in broader international databases. Furthermore, this study did not conduct quantitative analysis such as meta-analysis, which could statistically strengthen the consistency of relationships between variables. Based on these limitations, future research is recommended to develop more comprehensive instruments, conduct broader empirical testing involving various learning contexts, and conduct meta-analyses to provide a more robust picture of the effectiveness of various approaches to critical thinking assessment. Therefore, this synthesis is expected to serve as a reference for practitioners and researchers in developing better assessments that are more relevant to the needs of mathematics learning in today's era.

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