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Analyzing students' numeracy skills in contextual problems by critical thinking and mindset

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ABSTRACT

This study aims to describe the numeracy skills of 10th-grade students in solving contextual mathematical problems, reviewed based on their critical thinking and growth mindset levels. This research employed a qualitative approach with a case study method. The subjects were 108 10th-grade students at SMA Negeri 6 Padang, Data were collected through numeracy tests, critical thinking tests, growth mindset questionnaires, and in-depth interviews. Data analysis was descriptive, referring to indicators of numeracy, critical thinking, and growth mindset. The findings show that students with high critical thinking and high growth mindset levels exhibit optimal numeracy skills, categorized as high. Students with high critical thinking but moderate growth mindset still achieved high numeracy skills, while high critical thinking but low growth mindset resulted in moderate numeracy. Conversely, students with moderate critical thinking showed varied results; high growth mindset helped improve numeracy to moderate, whereas low growth mindset worsened outcomes. Students with low critical thinking, even with a high growth mindset, still demonstrated low numeracy. The combination of low critical thinking and low growth mindset yielded the lowest numeracy results. In conclusion, students with high critical thinking have better numeracy skills in analyzing information, using problem-solving strategies, and drawing logical conclusions.

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Introduction

The 21st century demands a workforce equipped with a sophisticated set of skills, with numeracy emerging as a foundational competency for navigating a complex, data-driven world (Makar, 2021; Khasanah & Murtafiah, 2022). Numeracy, or mathematical literacy, transcends basic arithmetic, encompassing the ability to apply, interpret, and communicate mathematical concepts to solve real-world problems (Tawil et al., 2024; OECD, 2023). It is a vital skill for critical decision-making, financial literacy, and informed citizenship (Nurani et al., 2023). Therefore, enhancing students' numeracy skills

is a primary objective of modern educational systems globally, including Indonesia (Janrino, 2024; Susanti & Puspitasari, 2023).

Despite its crucial importance, numerous national and international assessments reveal a persistent gap in students' numeracy performance. The Programme for International Student Assessment (PISA) consistently shows that students in many countries, including Indonesia, struggle with applying mathematical knowledge to contextual problems (OECD, 2023; Taqwanni, 2024). PISA 2022 results, for instance, highlight Indonesia's low ranking in mathematics, with a mean score significantly below the OECD average (OECD, 2023). Similarly, the Indonesian National Assessment (Asesmen Nasional) reports that a substantial percentage of high school students have not yet reached the minimum competency level in numeracy (Kemendikbudristek, 2023; Farihah, 2021). These findings underscore an urgent need to identify the factors influencing students' numeracy skills and to develop effective pedagogical strategies.

Contextual problems, embedded in students' daily lives, help them connect mathematics to the real world. Integrating these problems enhances understanding and retention of mathematical concepts. However, despite its importance, the implementation of numeracy skills remains suboptimal, as indicated by initial field studies showing many students have low numeracy. PISA 2022 results show Indonesia ranks 75th out of 79 countries in mathematics, with a score of 366, well below the OECD average. Indonesia's education report for 2023 indicates that only 47.62% of high school students met minimum numeracy competency. Assessment data from SMAN 6 Padang in 2023 also revealed that less than 50% of students achieved minimum numeracy competency. Previous research also supports the finding of low numeracy skills among students.

A preliminary study at SMAN 6 Padang (November 26-29, 2024) involved a numeracy test given to 97 10th-grade students with indicators: (1) using numbers and symbols for practical problem-solving; (2) analyzing information from various forms (graphs, tables); and (3) interpreting analysis results for decision-making. The results revealed students' difficulties in applying mathematical concepts, particularly in solving System of Linear Equations with Three Variables (SPLTV) problems, calculating, and providing clear interpretations or conclusions.

To address these deficiencies, a deeper understanding of the cognitive and affective factors that underpin numeracy is necessary. Critical thinking, defined as the purposeful, self-regulatory judgment that results in interpretation, analysis, evaluation, and inference, is a key cognitive driver of problem-solving success (Facione, 2020; Utami et al., 2022). Effective numeracy requires students to critically analyze information presented in various forms such as texts, graphs, and tables and apply logical reasoning to formulate solutions (Pahrudin et al., 2022; Agustin & Hidayati, 2022). Research consistently demonstrates a positive correlation between students' critical thinking abilities and their mathematical problem-solving performance (Nindiasari et al., 2021; Rohmah & Aini, 2022).

Beyond cognitive abilities, students' mindsets play a profound role in their academic achievement. Carol Dweck's theory of growth mindset, the belief that one's abilities can be developed through dedication and hard work, is particularly relevant to mathematics education (Dweck, 2006). A growth mindset fosters persistence, resilience, and a willingness to embrace challenges, which are essential for tackling complex, non-routine contextual problems (Hidayati & Saragih, 2023; Kurniawan et al., 2024). Conversely, students with a fixed mindset, who believe their intelligence is static, are more likely to give up when faced with difficulties, negatively impacting their learning outcomes and numeracy skills (Candra & Adelia, 2023; Rahayu et al., 2022). Previous studies have confirmed that a growth mindset significantly predicts better performance in mathematics and problem-solving tasks (Cholis, 2023; Sulisma & Hidayat, 2021).

Although the influence of critical thinking and growth mindset on mathematical achievement has been studied individually, there is a limited body of research that simultaneously investigates how these two factors interact to affect students' numeracy skills, particularly in the context of solving complex, contextual problems in Indonesia. Most existing research tends to focus on one of these variables or on general mathematical performance rather than the specific domain of numeracy (e.g., Fardah et al., 2021; Yulianto & Novitasari, 2023). Thus, a research gap exists in understanding the combined influence of students' critical thinking levels and their growth mindset on their ability to solve contextual mathematical problems.

This study aims to fill this gap by conducting an in-depth analysis of students' numeracy skills in solving contextual mathematical problems, reviewed based on their critical thinking and growth mindset levels. By exploring the interplay between these cognitive and affective factors, this research seeks to provide a more comprehensive understanding of student learning behaviors and to offer valuable insights for developing more effective and holistic mathematics education strategies (Ali et al., 2025; Dierkx et al., 2025; Ramadhani et al., 2025; Schmitt et al., 2025).

Preliminary findings at SMAN 6 Padang further reinforce this issue, revealing that less than half of Grade 10 students met minimum numeracy competency, particularly struggling with contextual problems involving graphs, tables, and System of Linear Equations in Three Variables (SPLTV). These difficulties indicate not only limited conceptual understanding but also weaknesses in higher-order reasoning skills required to justify solutions and draw meaningful interpretations (Andreadis et al., 2025; Buhl-Wiggers et al., 2025; Carpendale et al., 2025; Lawrence et al., 2025). While numeracy has been widely recognized as essential for informed decision-making and problem-solving, its development within Indonesian classrooms has remained suboptimal, partly due to insufficient integration of contextual problem-solving practices that connect mathematical ideas with students' lived experiences (Cheung et al., 2025; Ho et al., 2025; Kost et al., 2025; Payadnya et al., 2025).

Although previous studies have examined these variables separately in relation to mathematics performance, limited research has explored how the two interact to shape students' numeracy skills, especially in solving complex contextual problems (Gelbgiser & Gabay-Egozi, 2025; Ouyang & Chan, 2025). This study addresses that gap by analyzing students' numeracy abilities across different levels of critical thinking and growth mindset, aiming to provide a more comprehensive explanation of the cognitive affective interplay that underlies successful problem-solving. The findings are expected to inform more targeted instructional strategies that simultaneously cultivate higher-order reasoning and adaptive learning beliefs within the classroom.

Method

This research adopted a qualitative approach with a case study method. he study subjects were 108 10th-grade students at SMA Negeri 6 Padang. They were purposively sampled and categorized into groups based on their growth mindset (high, medium, low) and critical thinking levels (high, medium, low). Data were collected using: Numeracy tests, Critical thinking tests, Growth mindset questionnaires and In-depth interviews. The instruments included various tests and questionnaires, with validation and reliability calculations performed (e.g., test validity for critical thinking and numeracy, growth mindset questionnaire validity). Quantitative data from tests were analyzed by categorizing student scores into high, medium, and low levels based on mean and standard deviation. Qualitative data from interviews were reduced and presented descriptively, often using tables and textual descriptions to show relationships between categories.

Results and Discussions

The research findings were obtained through the distribution of a Growth Mindset questionnaire, a critical thinking ability test, a numeracy ability test, and interviews. The purpose of this study was to analyze and describe students' numeracy skills as reviewed from their levels of critical thinking and growth mindset.

The research was conducted at SMA Negeri 6 Padang, with the subjects being 108 10th-grade students. The questionnaire data was collected on June 12, 2025. This was followed by the critical thinking ability test on June 13, 2025, and the numeracy ability test on June 16, 2025. Finally, follow-up interviews were conducted with 18 students on June 18-19, 2025.

Data on student Growth Mindset was obtained through a questionnaire. The purpose was to group students into three categories based on their level of Growth Mindset: low, moderate, and high. The criteria for determining these Growth Mindset categories can be found in Table 1.

Table 1. Growth Mindset categories

Growth Mindset Categories	Information
$x < 67{,}34$	Low
$67{,}34 \leq x < 78{,}95$	Moderate
$x \geq 78{,}95$	High

Based on Table 1, it is known that students have varying levels of Growth Mindset. The majority of students, 59 out of 108, were in the moderate Growth Mindset category. Meanwhile, 26 out of 108 students had a low Growth Mindset, and 22 out of 108 students had a high Growth Mindset.

Next, Student data on critical thinking ability was obtained through a critical thinking ability test. The purpose was to group students into three categories based on their critical thinking levels: low critical thinking, moderate critical thinking, and high critical thinking. The criteria for determining these critical thingking categories can be found in Table 2.

Table 2. Critical Thingking categories

Critical Thinking Categories	Information
$x < 41{,}51$	Low
$41{,}51 \leq x < 81{,}87$	Moderate
$x \geq 81{,}87$	High

Based on Table 2, it is known that students have varying levels of critical thinking. The majority of students were in the moderate critical thinking category, with 72 out of 108 students. The smallest group was the high critical thinking level, with only 14 students.

Then, Data on students' numeracy skills were obtained through a numeracy ability test. The purpose was to identify and analyze the students' numeracy abilities. This numeracy test was administered to 18 students who were selected as research subjects. The selected subjects can be seen in Table 3 below.

Table 3. List of Research Subjects

Students	Critical Thinking Values	Critical Thinking Categories	*Growth Mindset Values*	*Growth Mindset Values*	Code
R3	93,75	High	85	High	A1
R19	93,75	High	79	High	A2
R25	93,75	High	78	Moderate	B1
R29	93,75	High	77	Moderate	B2
R83	87,5	High	68	Low	C1
R91	87,5	High	67	Low	C2
R5	81,25	Moderate	84	High	D1
R8	81,25	Moderate	82	High	D2
R26	81,25	Moderate	78	Moderate	E1
R27	81,25	Moderate	78	Moderate	E2
R84	75	Moderate	68	Low	F1
R88	68,75	Moderate	68	Low	F2
R2	37,5	Low	85	High	G1
R15	25	Low	80	High	G2
R41	37,5	Low	75	Moderate	H1
R44	37,5	Low	74	Moderate	H2
R86	31,25	Low	68	Low	I1
R107	31,25	Low	64	Low	I2

The categorization of students' numeracy skills is divided into 3 categories: low, moderate, and high, Furthermore, the results of grouping the 10th-grade students according to their numeracy skills are presented in Table 4.

Table 4. Numeration Ability Test Results

Students Categories	Code	Value	Information
High critical thinking & high growth mindset	A1	100,00	High
	A2	91,67	High
High critical thinking & moderate growth mindset	B1	91,67	High
	B2	83,33	High
High critical thinking & Low growth mindset	C1	75,00	Moderate
	C2	66,67	Moderate
Moderate critical thinking & high growth mindset	D1	83,33	High
	D2	66,67	Moderate
Moderate critical thinking & moderate growth mindset	E1	66,67	Moderate
	E2	58,33	Moderate
Moderate critical thinking & low growth mindset	F1	50,00	Low
	F2	33,33	Low
Low critical thinking & high growth mindset	G1	50,00	Low
	G2	41,67	Low
Low critical thinking & moderate growth mindset	H1	25,00	Low
	H2	16,67	Low
Low critical thinking & low growth mindset	I1	8,33	Low
	I2	0,00	Low

Interviews were the next step to describe students' numeracy skills as viewed from their levels of critical thinking and Growth Mindset. The interviews aimed to delve deeper into students' numeracy skills and the thought processes they used. Interviews were conducted with 18 selected research subjects who had previously completed the numeracy ability test.

The research results are categorized based on the levels of critical thinking and growth mindset, showing their influence on numeracy skills. Students with High Critical Thinking and High Growth Mindset, These students demonstrated optimal numeracy skills, categorized as high. They excelled in analyzing information, employing effective problem-solving strategies, and drawing logical conclusions. They showed persistence and a belief in intelligence development through effort and learning from mistakes. For instance, Subject A1 and A2 exhibited strong analytical and problem-solving abilities, even when facing difficulties. Students with High Critical Thinking and Moderate Growth Mindset, These students still achieved high numeracy skills. They could interpret data accurately and perform systematic calculations. Their critical thinking allowed them to normalize values for fair comparison. Students with High Critical Thinking and Low Growth Mindset: This group showed moderate numeracy. While capable of using mathematical symbols and interpreting data, they often struggled with providing comprehensive justifications or completing all aspects of a problem, indicating a lack of thoroughness or confidence in presenting their full reasoning.

Students with Moderate Critical Thinking: This group showed varied numeracy results. High Growth Mindset: Helped improve numeracy to a moderate level, as students were persistent and sought additional information to solve problems. Low Growth Mindset: Worsened numeracy outcomes. Students tended to give up quickly when faced with complex problems, lacking the perseverance to attempt solutions or seek alternative approaches. Students with Low Critical Thinking: High Growth Mindset: Despite having a high growth mindset, these students still showed low numeracy skills. They struggled with applying basic mathematical operations and analyzing data, often resorting to guesswork. Low Growth Mindset: The combination of low critical thinking and low growth mindset yielded the lowest numeracy results. These students often expressed frustration and reluctance to engage with complex problems, demonstrating a significant barrier to learning.

The findings consistently demonstrate the significant interplay between critical thinking, growth mindset, and numeracy skills. Students with higher levels of critical thinking and a stronger growth mindset are better equipped to tackle complex contextual mathematical problems. This aligns with

Facione's (1990) view of critical thinking involving interpretation, analysis, evaluation, and inference, all of which were evident in high-performing students. Similarly, Dweck's theory of growth mindset is supported, as students who believe their intelligence can develop through effort exhibited greater persistence and resilience in problem-solving.

The study highlights that critical thinking provides the cognitive framework for problem-solving, while a growth mindset fuels the perseverance needed to navigate challenges. Even students with high critical thinking benefited from a growth mindset, achieving better outcomes compared to those with a fixed mindset. Conversely, a low critical thinking level severely limited numeracy, even when a growth mindset was present, suggesting a foundational cognitive skill deficit. The most concerning results were observed in students with both low critical thinking and low growth mindset, indicating a need for comprehensive intervention focusing on both mindset change and explicit critical thinking instruction (Furnham & Cheng, 2025).

The findings of this study reveal a nuanced interaction between critical thinking, growth mindset, and numeracy skills, showing that students' performance in contextual mathematical problems is shaped not only by their cognitive abilities but also by their beliefs about learning. Students with high critical thinking and a strong growth mindset consistently demonstrated superior numeracy performance, evidenced by their ability to interpret complex data, justify multistep reasoning, and revise strategies when encountering errors behaviors that align with Facione's framework of analysis, evaluation, and inference. For example, students such as A1 and A2 were able to articulate the rationale behind each step in SPLTV problems and correct miscalculations independently, illustrating both cognitive proficiency and mindset-driven persistence. In contrast, students with high critical thinking but a low growth mindset often hesitated to complete their reasoning or provide full justifications, suggesting that self-doubt and fixed beliefs limited the potential of their cognitive skills (Duricy et al., 2025).

Meanwhile, students with moderate or low critical thinking showed fragmented numeracy performance regardless of mindset, frequently misinterpreting tables or relying on guesswork indicating that mindset alone cannot compensate for foundational reasoning deficits. These patterns highlight that critical thinking serves as the essential cognitive scaffold for numeracy, while a growth mindset amplifies students' willingness to persevere through complex tasks; thus, weaknesses in either dimension manifest in distinct forms of numeracy difficulties. This interplay underscores the need for integrated interventions that simultaneously strengthen analytical reasoning and cultivate adaptive learning beliefs to address the diverse numeracy challenges observed across student groups (Duricy et al., 2025b).

Conclusions

This research concludes that both critical thinking and growth mindset significantly influence students' numeracy skills in solving contextual mathematical problems. Students with high critical thinking demonstrate superior ability in analyzing information, applying problem-solving strategies, and drawing logical conclusions. Furthermore, a growth mindset positively impacts students' attitudes and persistence when facing contextual problems. The findings emphasize the need for educational interventions that foster both critical thinking abilities and a growth mindset to improve numeracy outcomes.

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