

STUDENTS' NUMERACY LITERACY SKILLS AND MATHEMATICAL HABITS OF MIND: A DIAGNOSTIC ANALYSIS

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ABSTRACT This study aims to conduct a diagnostic analysis of students by mapping their numeracy literacy (NL) and Mathematical Habits of Mind (MHOM) profiles, as well as examining the relationship between the two in solving non-routine problems. A mixed methods approach with a cross-sectional diagnostic design was employed, involving 120 elementary school students from three schools. Data were collected through a numeracy literacy diagnostic test, an MHOM questionnaire, structured observations, and in-depth interviews. The results indicate that students' numeracy literacy ability falls into the moderately low category, with an average mastery percentage of 46.13%. The main weakness was found in the interpreting process, with a mastery percentage of 34.45%, while students showed relatively better performance in the applying process. The MHOM profile was in the moderate category, with relatively high scores in perseverance and working accurately, but low scores in seeking patterns and flexible thinking. The correlation analysis revealed a significant positive relationship between overall numeracy literacy and Mathematical Habits of Mind ($r = 0.582$, $p < .001$). Qualitative findings further showed that students with weak flexible thinking tended to repeat ineffective procedures when facing unfamiliar or non-routine problems. These findings indicate that students' numeracy literacy difficulties are not only related to content mastery but also to dispositional barriers, particularly limited flexible thinking. This study contributes by providing a diagnostic mapping that links numeracy literacy difficulties with students' Mathematical Habits of Mind. The findings suggest that instructional interventions should strengthen flexible thinking and pattern seeking to support students' functional numeracy literacy.

Keywords: diagnostic analysis, flexible thinking, numeracy literacy, mathematical habits of mind

ABSTRAK Penelitian ini bertujuan untuk melakukan analisis diagnostik terhadap siswa dengan memetakan profil literasi numerasi dan Mathematical Habits of Mind (MHOM), serta mengkaji hubungan antara keduanya dalam menyelesaikan masalah non-rutin. Penelitian ini menggunakan pendekatan mixed methods dengan desain diagnostik cross-sectional, yang melibatkan 120 siswa kelas V dan VI dari tiga sekolah. Data dikumpulkan melalui tes diagnostik literasi numerasi, angket MHOM, observasi terstruktur, dan wawancara

mendalam. Hasil penelitian menunjukkan bahwa kemampuan literasi numerasi siswa berada pada kategori cukup rendah, dengan persentase penguasaan rata-rata sebesar 46,13%. Kelemahan utama ditemukan pada proses interpreting, dengan persentase penguasaan sebesar 34,45%. Hasil analisis korelasi menunjukkan adanya hubungan positif yang signifikan antara literasi numerasi secara keseluruhan dan Mathematical Habits of Mind ($r = 0,582$, $p < 0,001$). Temuan diagnostik lebih lanjut menunjukkan hubungan yang lebih kuat antara flexible thinking sebagai salah satu aspek MHOM dan kemampuan interpreting sebagai salah satu aspek literasi numerasi ($r = 0,651$, $p < 0,001$). Temuan ini menunjukkan bahwa kelemahan siswa dalam literasi numerasi berkaitan erat dengan hambatan disposisional, khususnya keterbatasan dalam flexible thinking. Penelitian ini berkontribusi dalam memberikan pemetaan diagnostik yang menghubungkan kesulitan literasi numerasi dengan Mathematical Habits of Mind siswa. Temuan ini menyarankan bahwa intervensi pembelajaran perlu mempertimbangkan penguatan flexible thinking untuk mendukung literasi numerasi fungsional siswa.

Kata-kata kunci: analisis diagnostik, flexible thinking, literasi numerasi, mathematical habits of mind

INTRODUCTION

Education in the 21st century requires a shift from a sole focus on mastering mathematical content toward the development of functional competencies and fundamental thinking dispositions. In the context of primary education, two key pillars that determine students' academic success and future life outcomes are numeracy literacy and Mathematical Habits of Mind (MHOM). Numeracy literacy is defined as an individual's ability to understand and use mathematical concepts, procedures, facts, and tools to explain and predict real-world phenomena, and it has become a core competency that students need to master (Joji, 2025). Meanwhile, MHOM refers to a set of behaviors, ways of thinking, and intellectual dispositions that enable students to become effective problem solvers, such as flexible thinking, perseverance, and pattern seeking (Tashtoush et al, 2022). The elementary school stage represents a crucial period for developing the foundation of these competencies, considering the importance of establishing strong mathematical reasoning from an early age (M et al., 2023).

Conceptually, Mathematical Habits of Mind function as cognitive-affective dispositions that underlie how students develop and apply numeracy literacy skills, particularly when dealing with non-routine problems that require flexibility and interpretive reasoning (Norman, 2022). Thus, MHOM does not merely serve as a supporting factor but is closely associated with the quality of students' numeracy literacy performance. The literature indicates a strong relationship between cognitive processes and affective dispositions in mathematics learning. Global studies, including recent PISA reports and Indonesia's National Assessment results, consistently highlight that many students continue to face significant challenges in applying numeracy concepts to solve contextual and non-routine problems (Dwirahayu et al., 2017).

These findings are supported by international research showing that numeracy competence is influenced not only by conceptual knowledge but also by students' thinking dispositions and attitudes toward mathematics. Low numeracy performance is often associated with mechanistic teaching approaches that do not sufficiently promote higher-order reasoning (Putri, 2024; Coşkun et al., 2024). On the other hand, MHOM has been identified as an important predictor of academic achievement and higher-order thinking skills, as these dispositions help students overcome difficulties and view problems from multiple perspectives (Dwirahayu et al., 2018; Haejelia et al., 2020). Empirical studies further demonstrate that interventions explicitly targeting metacognitive strategies and habits of mind can enhance conceptual understanding and problem-solving abilities (Badolo et al., 2025).

Despite these findings, a significant research gap remains. Although MHOM is believed to be associated with the quality of problem solving in numeracy literacy, most existing studies have not provided a detailed diagnostic analysis of how specific MHOM components, such as perseverance and flexible thinking, relate simultaneously to students' numeracy literacy profiles at the primary school level (Ünveren Bilgiç & Argün, 2018). Conventional analyses tend to present aggregated scores without explaining the underlying mechanisms of students' difficulties, whether these difficulties are related to insufficient conceptual knowledge or to the absence of appropriate thinking dispositions (Fan et al., 2021; Sujinah et al., 2024). Therefore, an integrated diagnostic analysis is needed to provide a deeper understanding of the interaction between thinking dispositions and functional numeracy performance as a basis for designing more targeted instructional interventions.

Based on this urgency, this study aims to conduct a comprehensive diagnostic analysis of elementary school students to map their numeracy literacy and Mathematical Habits of Mind profiles, as well as to examine the relationship between the two. More specifically, this study seeks to identify the strengths and weaknesses within numeracy literacy components and to determine which aspects of MHOM support or hinder students' problem-solving processes. Accordingly, the research questions of this study are as follows:

1. What is the profile of elementary students' numeracy literacy ability?
2. What is the profile of students' Mathematical Habits of Mind?
3. Is there a relationship between numeracy literacy and Mathematical Habits of Mind?
4. Which aspects of MHOM are most associated with students' weaknesses in numeracy literacy?

METHODS

This study employed a mixed methods approach with a quantitative-dominant design supported by qualitative data. The use of mixed methods was intended to

provide a comprehensive diagnostic description of students' Numeracy Literacy (NL) and Mathematical Habits of Mind (MHOM), as well as to examine the relationship between the two variables. The research design used in this study was a cross-sectional diagnostic design, in which data were collected at one point in time to map students' numeracy literacy profiles, identify their Mathematical Habits of Mind, and analyze the association between these two aspects.

The participants of this study were fifth- and sixth-grade students from three public elementary schools in Medan, namely SDN 066050, SDN 064983, and SDN 064984. The total sample consisted of 120 students drawn from selected classes. The schools and classes were selected using purposive sampling based on representativeness and accessibility of data. Within the selected classes, total sampling was applied, meaning that all students in the selected classes were involved as research participants for the descriptive and correlation analyses.

Data were collected using four instruments: a numeracy literacy diagnostic test, a Mathematical Habits of Mind questionnaire, a structured observation sheet, and an in-depth interview guide. The numeracy literacy diagnostic test was used to measure students' mastery of numeracy literacy based on cognitive processes, including applying, formulating, and interpreting. The MHOM questionnaire was used to assess students' mathematical thinking dispositions, including perseverance, working accurately, seeking patterns, and flexible thinking. Structured observations were conducted to record students' behaviors during problem-solving activities, while in-depth interviews were used to explore students' reasoning processes, particularly in relation to their difficulties in solving non-routine numeracy problems. Instrument validity was established through expert judgment by mathematics education specialists to ensure that the content of each instrument was aligned with the intended indicators. The reliability of the Mathematical Habits of Mind questionnaire was examined using Cronbach's Alpha, resulting in a coefficient of $\alpha = 0.87$, which indicates a high level of internal consistency. The qualitative instruments, including the observation sheet and interview guide, were reviewed to ensure their relevance to the diagnostic focus of the study.

The quantitative data were analyzed using descriptive and inferential statistics. Descriptive analysis was used to determine students' numeracy literacy and MHOM profiles by calculating mean scores, standard deviations, and mastery percentages. The categorization of students' numeracy literacy mastery and Mathematical Habits of Mind scores was determined based on the criteria presented in Tables 1 and 2.

Table 1. Criteria for Numeracy Literacy Mastery

Mastery Percentage	Category
0%–20%	Very low
21%–40%	Low

Mastery Percentage	Category
41%–55%	Moderately low
56%–70%	Moderate
71%–85%	High
86%–100%	Very high

Table 2. Criteria for Mathematical Habits of Mind Scores

Mean Score Interval	Category
1.00–2.40	Very low
2.41–2.80	Low
2.81–3.40	Moderate
3.41–4.20	High
4.21–5.00	Very high

Before conducting correlation analysis, assumption tests were performed. The normality of the data was tested using the Kolmogorov–Smirnov test, while the linearity test was used to examine whether the relationship between numeracy literacy and MHOM was linear. Since the assumptions were met, Pearson correlation analysis was used to examine the relationship between students' numeracy literacy and Mathematical Habits of Mind. Additional correlation analysis was also conducted to identify the relationship between specific aspects of MHOM and numeracy literacy, particularly flexible thinking and interpreting ability.

The qualitative data obtained from observations and interviews were analyzed using thematic analysis. The analysis involved data reduction, coding, categorization, and theme development. These qualitative findings were used to support and clarify the quantitative results, especially in explaining students' difficulties in solving non-routine numeracy problems. To ensure the credibility of the qualitative data, triangulation was carried out by comparing data from tests, questionnaires, observations, and interviews. Peer debriefing was also conducted to strengthen the consistency of the interpretation.

FINDING AND DISCUSSION

1. Profile of Elementary Students' Numeracy Literacy Skills

The results of the descriptive analysis of the Numeracy Literacy (NL) diagnostic test scores indicate that, overall, elementary school students' numeracy literacy ability falls into the moderately low category. This study involved 120 fifth-grade students. Table 1 presents the descriptive statistics of students' numeracy literacy ability.

Table 1. Descriptive Statistics of Students' Numeracy Literacy Skills

Variable	N	Ideal Maximum Score	Mean (M)	Standard Deviation (SD)	Mastery Percentage (%)	Category
Numeracy Literacy (Total)	120	40	18.45	6.12	46.13%	Moderately low

The average level of students' mastery was 46.13%, placing their numeracy literacy ability in the moderately low category. This indicates that students' abilities remain below the functional competencies expected in numeracy literacy. The relatively high standard deviation (SD = 6.12) also suggests a considerable disparity in performance among students in the sample. This finding is consistent with previous studies indicating that students' mathematical literacy and numeracy-related performance still require serious attention, particularly in contextual and problem-solving situations (Joji, 2025; Kir & Aksu, 2024; Malasari et al., 2019).

Identification of Strengths and Weaknesses in Numeracy Literacy Aspects

A more in-depth diagnostic analysis was conducted by disaggregating scores based on cognitive processes (Kir & Aksu, 2024). Table 2 presents the percentage of students' mastery across the assessed cognitive processes.

Table 2. Percentage of Numeracy Literacy Mastery by Cognitive Process

Cognitive Process	Mastery Percentage (%)	Category
Applying	58.75%	Moderate
Formulating	45.20%	Moderately low
Interpreting	34.45%	Low
Overall Average	46.13%	Moderately low

The main weakness was identified in the interpreting cognitive process, with a mastery percentage of 34.45%. This process requires students to evaluate mathematical results and draw conclusions within complex contextual situations. In contrast, students demonstrated relatively better performance in the applying domain, with a mastery percentage of 58.75%. This finding indicates that students are more capable of applying mathematical procedures than interpreting mathematical results in context.

The dominance of procedural skills in the applying domain reflects a learning pattern that remains largely mechanistic and has not yet optimally supported the

development of higher-order thinking skills, particularly in interpreting contextual problems (Syaiful & Puspayanti, 2023). Difficulties at the interpreting stage are often associated with instructional approaches that are overly procedural and insufficient in fostering students' reasoning and problem-solving abilities (Faulkner et al., 2023).

2. Profile of Mathematical Habits of Mind (MHOM)

The measurement of Mathematical Habits of Mind (MHOM) was conducted using a Likert-scale questionnaire and structured observation as a form of method triangulation to capture students' thinking dispositions. Table 3 presents students' MHOM scores across four main indicators.

Table 3. Descriptive Statistics of Mathematical Habits of Mind (MHOM)

MHOM Indicator	Mean (M) (Scale 5)	Category
Perseverance	4.15	High
Working Accurately	3.88	High
Seeking Patterns	2.55	Low
Flexible Thinking	2.30	Very low
Overall MHOM Average	3.22	Moderate

Overall, students' Mathematical Habits of Mind fall into the moderate category, with an average score of 3.22. The results show that students reported high levels of perseverance ($M = 4.15$) and working accurately ($M = 3.88$). However, both questionnaire results and observational data reveal significant weaknesses in seeking patterns ($M = 2.55$) and, particularly, in flexible thinking ($M = 2.30$).

Qualitative observation confirmed that when students were faced with numeracy problems involving unfamiliar contexts or requiring non-standard solutions, they tended to repeat the same unsuccessful procedure without modifying their strategies. This behavior confirms that low flexible thinking is a core issue in students' problem-solving dispositions at the elementary level (Yandari et al., 2019). Thus, students' difficulties are not only related to mathematical content mastery but also to their limited ability to adapt their thinking strategies when routine procedures are no longer effective.

3. Analysis of the Relationship Between Numeracy Literacy and Habits of Mind

Prior to conducting Pearson correlation analysis, assumption tests were performed to ensure the appropriateness of using parametric statistics. The results of the Kolmogorov–Smirnov normality test indicate that both Numeracy Literacy and Mathematical Habits of Mind data were normally distributed. The significance values were 0.087 for Numeracy Literacy and 0.092 for Mathematical Habits of Mind, indicating that both values were greater than .05. Therefore, the normality assumption was satisfied.

Subsequently, a linearity test was conducted to examine the relationship between the two variables. The results show that the relationship between Numeracy Literacy and Mathematical Habits of Mind was linear, with a deviation from linearity significance value of 0.214, which was greater than .05. Based on these findings, it can be concluded that the data meet the assumptions required for Pearson correlation analysis.

Table 4. Pearson Correlation Between Numeracy Literacy and Mathematical Habits of Mind

Variables Correlated	Correlation Coefficient (r)	Significance (p)	Relationship
Numeracy Literacy Total and MHOM Total	0.582	< 0.001	Positive, moderate-to-strong

Significant at the alpha level of .01 (two-tailed).

The results indicate a significant positive correlation between total Numeracy Literacy scores and total Mathematical Habits of Mind scores, with a moderate-to-strong relationship ($r = 0.582$, $p < .001$). This finding empirically supports previous studies suggesting that Mathematical Habits of Mind are closely related to mathematical ability, mathematical comprehension, and higher-order mathematical thinking (Dwirahayu et al., 2017; Norman, 2022; Tashtoush et al., 2022). To complement the statistical interpretation, the 95% confidence interval indicates that the correlation coefficient lies within a stable range, approximately $CI\ 95\% = 0.45-0.69$, thereby reinforcing the reliability of the observed relationship.

Furthermore, this finding is consistent with previous research highlighting that mathematical thinking dispositions play an important role in supporting mathematical literacy, problem-solving, and higher-order thinking abilities (Badolo et al., 2025; Malasari et al., 2019; Nuurjannah et al., 2018). Thus, this relationship suggests that cognitive and affective dimensions are inherently interconnected in shaping students' mathematical performance.

Qualitative analysis through in-depth interviews with students exhibiting low numeracy literacy and weak Mathematical Habits of Mind revealed that students tended to experience mental blocks when routine procedures failed. They often persisted in repeating the same ineffective strategies without attempting alternative approaches, reflecting limitations in flexible thinking.

These findings reinforce the quantitative results by providing a more contextualized understanding of students' cognitive processes. Thus, the relationship between flexible thinking and interpreting ability is not only identified statistically but also confirmed through students' observable problem-solving behaviors.

From a practical perspective, these findings suggest that instructional interventions should not focus solely on content mastery but also on the development of thinking dispositions, particularly flexibility in selecting and evaluating problem-solving

strategies as an integral component of improving numeracy literacy (Nuurjannah et al., 2018).

4. Implications and Contributions of the Study

The findings of this study reinforce the role of social constructivist theory proposed by Lev Vygotsky in the context of functional mathematics learning. They suggest that cognitive-affective dispositions, as reflected in Mathematical Habits of Mind, serve as a foundational basis for students' cognitive performance in numeracy literacy.

From this perspective, Mathematical Habits of Mind function as internal mechanisms that support processes of internalization and self-regulation, enabling students to organize learning experiences and actively construct mathematical meaning. Thus, numeracy literacy is not merely the result of conceptual mastery but rather a manifestation of the dynamic interaction between cognitive abilities and thinking dispositions.

This integrated diagnostic analysis provides a clear framework for designing targeted instructional interventions (Fan et al., 2021; Sujinah et al., 2024). First, a disposition-based diagnosis enables teachers to recognize that students' difficulties in reasoning and interpreting may be more closely associated with weak Mathematical Habits of Mind rather than solely with insufficient content knowledge. Second, instructional interventions should prioritize the development of flexible thinking and pattern seeking, for example through tasks that encourage multiple solution strategies or open-ended exploration. These dispositions serve as essential prerequisites for improving students' functional numeracy literacy.

The main limitation of this study lies in its cross-sectional design, which restricts the ability to draw causal inferences. Therefore, future research is recommended to employ longitudinal or experimental designs to examine the effectiveness of interventions specifically aimed at strengthening Mathematical Habits of Mind, particularly those that are underdeveloped, in improving students' numeracy literacy.

Overall, these findings highlight the need to shift mathematics instruction from a focus on procedural knowledge toward the development of adaptive mathematical thinking dispositions as a fundamental foundation for functional numeracy literacy.

CONCLUSIONS AND RECOMMENDATIONS

Based on the comprehensive diagnostic analysis, it can be concluded that students' Numeracy Literacy (NL) ability falls into the moderately low category, primarily due to weaknesses in the cognitive process of interpreting. Students showed relatively better performance in applying mathematical procedures, but they still experienced difficulties in interpreting mathematical results and drawing conclusions in contextual and non-routine situations. The profile of students' Mathematical Habits of Mind (MHOM) was generally in the moderate category, with stronger dispositions

in perseverance and working accurately, but weaker dispositions in seeking patterns and flexible thinking. The correlation analysis showed a significant positive relationship between students' numeracy literacy and Mathematical Habits of Mind ($r = 0.582$, $p < .001$), indicating that students' functional numeracy performance is associated not only with cognitive ability but also with mathematical thinking dispositions. Qualitative findings further revealed that students with limited flexible thinking tended to repeat ineffective procedures when routine strategies failed. Therefore, this study provides a diagnostic map for teachers and policymakers to design more targeted instructional interventions. In practice, mathematics learning should not only focus on procedural practice and content mastery, but also strengthen students' flexible thinking and pattern-seeking dispositions through contextual, open-ended tasks that allow multiple solution strategies. Future studies are recommended to conduct longitudinal or experimental research to examine the effectiveness of Mathematical Habits of Mind-based interventions in improving students' numeracy literacy.

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