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Mapping Elementary Students' Numeracy Literacy Skills: A Comprehensive Analysis Based on Six Indicators

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Abstract

Developing students' numeracy literacy skills is essential in the 21st century, as these skills enable learners to interpret quantitative information, solve real-world problems, and make reasoned decisions. However, the mastery of numeracy literacy among elementary students in Indonesia remains uneven across regions. This study aimed to analyze the numeracy literacy skills of elementary school students in Region III Cirebon to identify their strengths and weaknesses across different competency indicators. A qualitative descriptive approach was employed, involving five elementary schools representing the region. Data were collected through numeracy literacy tests and semi-structured interviews. The instrument was developed based on six indicators: communication, representation, reasoning and argumentation, mathematization, problem-solving strategy, and the use of symbolic, formal, and technical operations. Data were analyzed through data reduction, data presentation, and conclusion drawing. The findings showed that students' overall numeracy literacy skills ranged from medium to low levels. Communication skills were relatively strong, while reasoning, argumentation, and problem-solving strategies were moderate. In contrast, mathematization and symbolic operation skills were notably weak. These findings suggest that numeracy learning in elementary schools still emphasizes procedural understanding rather than conceptual and contextual reasoning. The study contributes to educational research by providing empirical evidence of the current state of numeracy literacy in elementary schools and offers implications for curriculum development and teacher training aimed at fostering deeper mathematical understanding and application.

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INTRODUCTION

Learning mathematics today goes beyond memorization and calculation. It emphasizes developing students' logical, critical, and analytical thinking skills, collectively known as numeracy literacy. Students with strong numeracy literacy can better understand mathematical concepts, interpret data, and make evidence-based decisions. According to the OECD (2019), numeracy refers to the ability to access, use, interpret, and communicate mathematical information to address various real-life situations. Similarly, the Ministry of Education, Culture, Research, and Technology (2020) and Aini et al. (2024) highlight that numeracy literacy underpins 21st-century competencies such as critical thinking and problem-solving skills essential for navigating global challenges. Strengthening

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students' numeracy literacy is therefore vital to preparing an adaptive, intelligent, and competitive generation in the digital era.

In the context of mathematics education, numeracy literacy represents a multidimensional construct that integrates cognitive, analytical, and applied competencies. It encompasses the capacity to comprehend, interpret, and utilize mathematical information in diverse real-life contexts. Several authoritative institutions have conceptualized the dimensions of numeracy literacy. The Ministry of Education, Culture, Research, and Technology (2020) identifies core components such as data interpretation, understanding of mathematical operations, and contextual problem-solving. In a similar vein, the National Education Standards Agency (BNSP, 2018) delineates indicators including logical reasoning, pattern recognition, and the ability to represent information through graphical or tabular forms. Furthermore, UNESCO (2017) underscores quantitative reasoning, comprehension of measurement and comparison, and the application of numerical understanding in informed decision-making. Collectively, these perspectives indicate that numeracy literacy extends beyond procedural computation, encompassing higher-order thinking processes such as critical reasoning, problem-solving, and decision-making based on quantitative evidence.

Several researchers have examined students' numeracy literacy skills across different educational levels, ranging from elementary to senior high school. At the elementary level, studies by Kalsum and Sulastri (2023) and Dekar et al. (2025) have provided important insights. Kalsum and Sulastri (2023) identified three key indicators of numeracy literacy, namely: (1) the use of various numbers and symbols related to basic mathematics in solving everyday problems, with a percentage of 8.16% (very low category); (2) the ability to analyze information presented in multiple forms (graphs, tables, charts), with a percentage of 26.53% (low category); and (3) the ability to interpret analytical results for prediction and decision-making, with a percentage of 59.18% (medium category). Meanwhile, Dekar et al. (2025) emphasized three main challenges in improving numeracy literacy: limited teaching materials, inadequate teacher training, and behavioral issues related to student character.

At the junior high school level, research conducted by Nuryami (2024) and Sundari et al. (2025) also revealed similar trends. Nuryami (2024) found that students' numeracy literacy skills remain at a low level within the context of the independent learning curriculum. In line with this, Sundari et al. (2025) reported that students' average numeracy test scores reached only 29.3, with merely 16% achieving the minimum competency level in statistical reasoning. At the senior high school level, Rahmawati et al. (2024) and Refwalu et al. (2025) found that students' numeracy literacy skills were generally moderate to low. Rahmawati et al. (2024) identified an overall moderate competency, while Refwalu et al. (2025) showed that only high-performing students could meet all numeracy literacy indicators. Students with moderate abilities struggled with using mathematical symbols and interpreting data representations, whereas low-performing students failed to meet all indicators, resulting in an overall low category (22.58%).

The findings of these previous studies indicate that most analyses of numeracy literacy have been limited to three core indicators: (1) using numbers and symbols to solve everyday problems, (2) analyzing information presented in various formats, and (3) interpreting results for prediction and decision-making. However, research adopting a more comprehensive framework—such as the six indicators proposed by Windisch (2015), which include communication skills, mathematization skills, representation skills, reasoning and argumentation skills, problem-solving strategy selection, and the ability to use symbolic and technical operations—remains scarce. This gap underscores the need for a broader and more integrative assessment of numeracy literacy. Therefore, the present study aims to analyze the numeracy literacy skills of elementary school students in Region III Cirebon based on these six indicators, in order to obtain a more holistic picture of students' competencies. The results are expected to provide empirical evidence for educational policymakers and practitioners in designing targeted interventions to strengthen numeracy literacy at the foundational level.

METHOD

This research is a qualitative study using a descriptive approach, which aims to describe the social reality that occurs in a complete and in-depth manner (Cresswell, 2012). Qualitative

descriptive research is conducted through an analysis of students' answers to numeracy literacy questions in the context of everyday life. Purposive sampling technique was used to select research subjects, namely a sampling technique that represents the population with adequate accuracy Nassaji, 2015). The subjects in this study were fifth-grade elementary school students in Region 3 Cirebon, including Cirebon City, Cirebon Regency, Indramayu Regency, Majalengka Regency, and Kuningan Regency. In each city and regency, one school was selected as the target in this study, the following data on the number of research subjects in each region.

Table 1. Target Data and Research Subjects

No	Region 3 Cirebon	Number of Subjects
1	Cirebon City	26 Students
2	Cirebon Regency	20 Students
3	Indramayu Regency	16 Students
4	Majalengka Regency	13 Students
5	Kuningan Regency	25 Students

The data collection techniques used are test methods, interview methods, and recordings. The instrument used in this research was developed based on Windisch's (2015) numeracy literacy indicators which consist of 6 indicators. In detail, the indicators and questions used to analyze numeracy literacy skills are shown in table 2.

Table 2. Indicators and Questions Used

No	Indicators	Indicator Description	Questions Used
1	Communication Skills	The ability to express and explain mathematical ideas orally or in writing to others in real-life contexts.	Ana wants to buy 4 pencils and 2 notebooks at Toko Sejahtera. The price of one pencil is Rp1,500, while the price of one notebook is Rp6,000. If Ana has Rp20,000, is it enough to buy these items? Explain your reasoning with clear calculations!
2	Mathematization Ability	The ability to transform real-world situations into mathematical models (abstractions), as well as to relate mathematical results back to the initial context.	Budi has a watermelon that is divided into 12 pieces. He ate 3 pieces and gave 2 pieces to his friend. Based on this problem, answer the following questions: a. Write a fraction that shows the watermelon Budi has eaten. b. Write a fraction that shows the watermelon he gave to his friend. c. How many pieces of watermelon are left?
3	Representation Ability	The ability to use and interpret various representations (tables, graphs, diagrams, symbols) to understand and solve problems.	The following is the number of books borrowed from the school library during one week: • Monday: 6 books • Tuesday: 8 books • Wednesday: 12 books • Thursday: 2 books • Friday: 9 books Based on the above problem, answer the following questions: a. Draw a simple line graph based on the data above. b. On which day were the fewest books borrowed? Explain your reasoning!
4	Reasoning and Argumentation Skills	The ability to think logically, construct arguments, draw conclusions, and provide mathematical reasons in a coherent and consistent manner.	Susan arranged the stones in the following pattern: • Row 1: 3 stones • Row 2: 6 stones • Row 3: 9 stones • Row 4: 12 stones • Based on the problem above, answer the following questions: a. If this pattern continues, how many stones will there be in row 8? b. Explain how you found the answer.

5	Ability to Choose Strategies to Solve Problems	The ability to identify, design, and apply appropriate strategies to solve mathematical problems in various contexts.	Badu leaves for school at 6:00 a.m. and arrives at 6:45 a.m. Based on this problem, answer the following questions: a. How long does it take Badu to get to school? b. What strategy can be used to easily calculate the time difference?
6	Ability to Use Symbolic, Formal, and Technical Language and Operations	The ability to use symbols, notations, formulas, and formal mathematical language to perform manipulations and calculations accurately.	Nani's house is 4 km from the market. Every day, she shops at the market and walks home. Based on this problem, answer the following questions: a. Write the mathematical operation to calculate the total distance Nani travels in a day. b. What is the total distance Nani travels to the market in one week?

The data analysis technique refers to Miles et al. (2014), which consists of three stages: 1) Data reduction, 2) Data presentation, and 3) Conclusion drawing. Meanwhile, the calculations used by the researchers in analyzing the results of student answers are based on Asrul & Rosnita (2014) as follows.

$$P = \frac{f}{N} \times 100\%$$

Description:
P: Percentage of ability
f: Score obtained
N: Maximum score

The following are the categories of students' numeracy literacy ability levels, adapted from Asrul & Rosnita (2014) as follows:

Table 3. Numeracy Literacy Ability Category

Percentage	Category
$80\% < P \leq 100\%$	Very high
$60\% < P \leq 80\%$	High
$40\% < P \leq 60\%$	Moderate
$20\% < P \leq 40\%$	Low
$0\% \leq P \leq 20\%$	Very Low

Apart from being presented in percentage form, several test and interview results were analyzed descriptively and presented in six parts, namely: (1) communication skills, (2) mathematization skills, (3) representation skills, (4) reasoning and argumentation skills, (5) ability to choose strategies to solve problems, and (6) ability to use language and symbolic, formal and technical operations.

RESULTS AND DISCUSSION

Students' numeracy literacy skills were measured using a numeracy literacy thinking skills test consisting of six indicators. An analysis of the results of the numeracy literacy thinking skills test for students in five elementary schools in Region 3 Cirebon involved in this study is presented in Table 4.

Tabel 4. Results of the Numeracy Literacy Ability Test for Students in Region 3 Cirebon

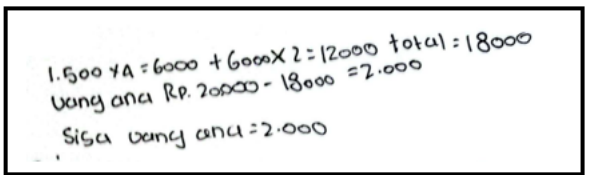
Indikator	Persentase	Kategori
Communication Skills	72%	High
Mathematical Skills	40%	Low
Representational Skills	52%	Moderate
Reasoning and Argumentation Skills	57%	Moderate
Problem-Solving Strategy Selection	48%	Moderate
Symbolic, Formal, and Technical Language and Operations	40%	Low

Based on Table 4 above, it can be seen that in general, the numeracy literacy skills of students in Region 3 Cirebon are included in the medium to low category. The results of this study are in line

with the results of research by Iswara (2022); Rahmawati, et al (2023); and Sehuwaky & Mastuti (2021) which found that students' numeracy literacy skills are in the medium category. The following is a description of each indicator of students' numeracy literacy skills in Region 3 Cirebon.

Communication Skills

Based on the analysis results on communication ability indicators, from 100 students who took the test, the following details were obtained, as many as 40 students (40%) had very high communication abilities, 24 students (24%) had high communication abilities, 16 students (16%) had moderate communication abilities, 4 students (4%) had low communication abilities and 16 students (16%) had very low communication abilities. The following are the results of the researcher's (R) work and interviews with students who had moderate communication abilities (subject 63 (S 63)).



Subject 63 (S 63)

$1500 \times 4 = 6000 + 6000 \times 2 = 12000\ amount = 18000$
Ana's money Rp 20000-18000 = 2.000
Ana's remaining money = 2.000

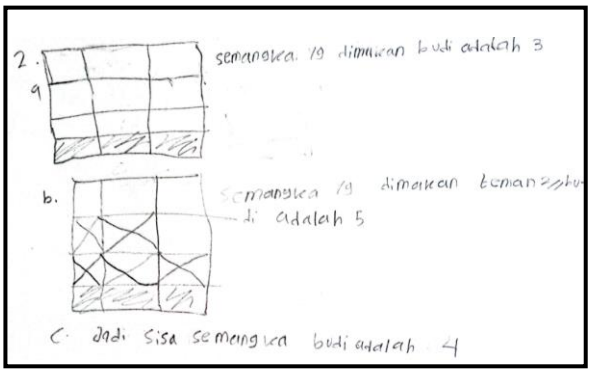
Translation of subject 63's answer

R : Please tell us the process of solving question no. 1.
S 63 : Ana bought 4 pencils and 2 notebooks, sir, because the price of a pencil is one thousand five hundred, so the total is six thousand, sir, because 4 times 1500 is 6000. Then the price of 1 notebook is six thousand, so 2 notebooks are 12000, sir.
R : Okay, good, what next?
S 63 : Because Ana's total shopping is 18,000, so Ana still has enough money, Sir, and there is still 2,000 left, Sir, from 20,000 minus 18,000.
R : Because Ana's total shopping is 18,000, so Ana still has enough money, sir, and there is still 2,000 left, sir, from 20,000 minus 18,000.
S 63 : Yes, sir
R : If I say 2000 = 5000, is that okay? (while showing 2000 and 5000 notes)
S 63 : No sir, the difference is between 2000 and 5000
R : Okay, good, take another look at your answer!
S 63 : Yes sir, here I wrote 12000 = 18000 (While showing the answer)
R : Be careful when writing symbols and symbols in mathematics.
S 63 : Yes, sir.

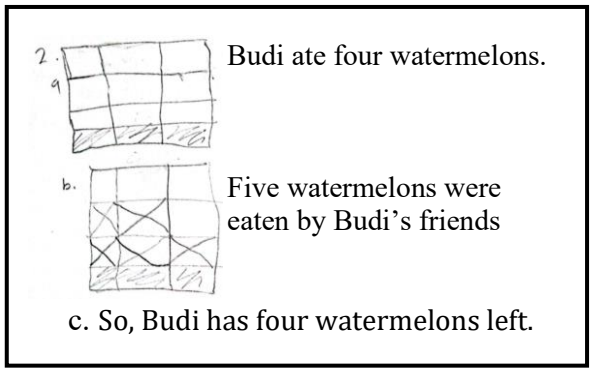
Based on the results of student work and interview results, it can be concluded that subject 63 has good oral communication skills, but not so with his written communication. This can be seen from the error of subject 63 when writing 12000 total = 18000. This error occurred because the student did not understand the meaning of "=" correctly. Subject 63 was able to interpret the equal symbol (=) in the case given by the researcher in a real way, namely when asking about 2000 and 5000 money. This made subject 63 aware of the mistakes that had been made when solving the problem. This finding is in line with the results of research by Basri et al., (2019) which found that students' errors in understanding the meaning of "=", had an impact on errors in interpretation.

Mathematical Ability

Based on the results of the analysis of the mathematical ability indicators, from 100 students who took the test, the following details were obtained, as many as 16 students (16%) had very high mathematical abilities, 8 students (8%) had high mathematical abilities, 12 students (12%) had moderate mathematical abilities, 28 students (28%) had low mathematical abilities and 36 students (36%) had very low mathematical abilities. The following are the results of the researcher's work and interviews (R) with students who have low mathematical abilities (subject 12 (S 12))



Subject 12 (S 12)



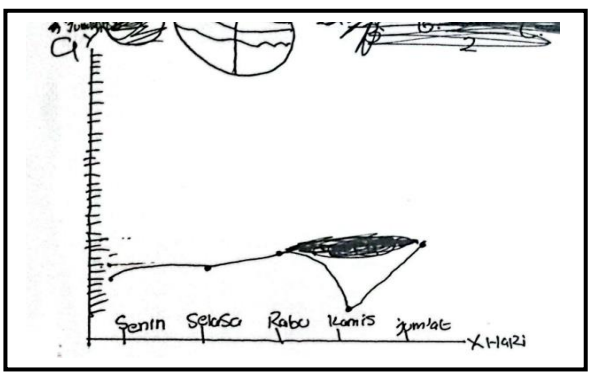
Translation of subject 12's answer

R : Why did you make 12 squares in the picture? (pointing to the student's drawing)
S 12 : Because the watermelon was divided into 12 pieces, sir.
R : Oh, I see. Why are there 3 squares shaded in answer a?
S 12 : Budi ate it, sir.
R : What was asked for in question a? (asks the student to reread question 2a)
S 12 : Write a fraction that shows how many watermelons Budi ate.
R : So, what's the answer
S 12 : (pauses and thinks)
R : How?
S 12 : You're confused about writing fractions.
R : Okay, that's okay. For question 2b, how many did Budi's friends eat?
S 12 : (pauses and reads the question) It turns out Budi's friends ate 2, sir, not 5.
R : So how many pieces of watermelon are left?
S 12 : (thinking and counting again) twelve minus five, sir, is 7.

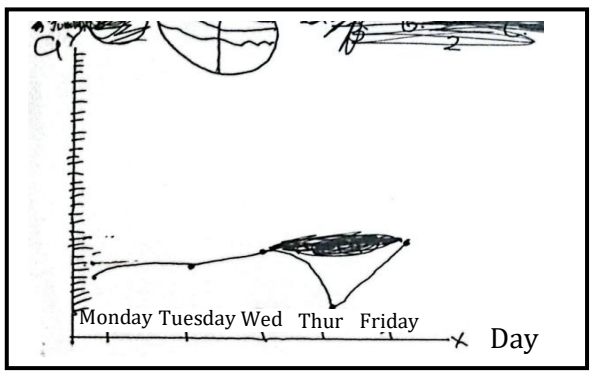
Based on student work and interviews, it can be concluded that subject 12 has poor mathematical abilities, as evidenced by the student's inability to convert the drawings into fractions. This indicates that fractions are indeed a difficult topic for students. Several studies have also shown that students experience difficulties with fractions (Bingham & Rodriguez, 2019; Sari et al, 2024; Rahmawati & Wahyudin, 2022).

Representation Ability

Based on the results of the analysis of the mathematical ability indicators, from 100 students who took the test, the following details were obtained, as many as 28 students (28%) had very high representation abilities, 20 students (20%) had high representation abilities, 8 students (8%) had medium representation abilities, 12 students (12%) had low representation abilities and 32 students (32%) had very low representation abilities. The following are the results of the researcher's work and interviews (R) with students who had medium representation abilities (subject 77 (S 77))



Subject 77 (S 77)



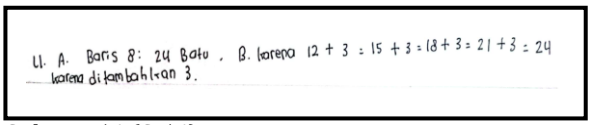
Translation of subject 77's answer

R : What does the left side represent? (Pointing to the eleven lines on the left side of Figure S 77)
S 77 : Number of books, sir.
R : How many books were there on Monday?
S 77 : 6 books, sir.
R : Why are there 6? Where did that come from?
S 77 : (Counting the number of marks on the left) There are six, sir.
R : How many books were there on Friday?
S 77 : 9 books, sir.
R : How many books were there on Wednesday?
S 77 : 12 books, sir.
R : Why does the height appear higher in the figure on Friday?
S 77 : (Pause for a moment and think) Yes, sir.
R : Is that correct?
S 77 : No, sir, there should be more on Wednesday.

Based on the results of student work and interview results, it can be concluded that subject 77 has moderate representation ability, this can be seen from the results of subject 77's work even though it is not optimal. Subject 77 did not label with numbers on the vertical axis of the diagram, this resulted in subject 77 making several errors in determining the height of the points on the line diagram. In the interview, it appeared that S 77 was hesitant and doubtful with his answer after being confronted with the problem of height and inconsistent number of books, this gave S 77 cognitive conflict. Providing cognitive conflict followed by providing scaffolding is one strategy in remediating misconceptions (Hasanah et al. 2022; Kusmaryono et al, 2020; Miterianifa et al, 2020; Tay & Toh, 2023).

Reasoning and Argumentation Skills

Based on the results of the analysis of the reasoning and argumentation ability indicators, from 100 students who took the test, the following details were obtained, as many as 32 students (32%) had very high reasoning and argumentation abilities, 20 students (20%) had high reasoning and argumentation abilities, 16 students (16%) had moderate reasoning and argumentation abilities, 4 students (4%) had low reasoning and argumentation abilities and 28 students (28%) had very low reasoning and argumentation abilities. The following are the results of the researcher's work and interviews (R) with students who had high reasoning and argumentation abilities (subject 56 (S 56))



Subject 56 (S 56)

4. A. The 8 th line : 24 stones
B. Because 12+3 = 15+3 = 18+3 =21+3=24 because 3 was added

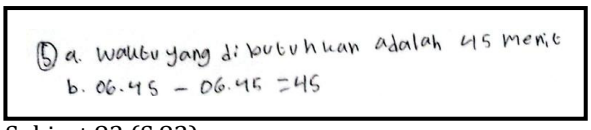
Translation of subject 56's answer

R : How did you get the number of bricks in the 8th row?
S 56 : I added 3 bricks, Sir, for the next row.
R : Why did you add 3 for the next row?
S 56 : Because from row 1 to row 2, you add 3, from row 2 to row 3, you add 3, and so on, Sir.
R : Okay
R : 1
S 56 : 15
R : How much is 15 + 3?
S 56 : 18
R : Does 15 = 18?
S 56 : No, Sir
R : Why did you write 12 + 3 = 15 + 3?
S 56 : Oh yes, sir, that's wrong, I just realized.

Based on the results of the student's work and the results of the interview, it can be concluded that subject 56 has good reasoning skills, this can be seen from S 56's answer regarding his reasons for adding 3 stones in the next row. However, subject 56 made a mistake when writing 12 + 3 = 15 + 3. This error occurred because the student did not understand the meaning of "=" correctly. S 56 realized the error he made when the researcher gave the two statements separately. This made subject 56 aware of the error he had made when writing that 12 + 3 = 15 + 3 = 18 + 3 = 21 + 3. This finding shows the importance of students' understanding of the concept of "=", one of which is knowing that the "equal to" symbol is used to express relations (Ardiansari et al., 2023).

Ability to Choose Strategies to Solve Problems

Based on the analysis results of the indicator of the ability to choose strategies to solve problems, from 100 students who took the test, the following details were obtained, as many as 24 students (24%) had a very high ability to choose strategies to solve problems, 20 students (20%) had a high ability to choose strategies to solve problems, 16 students (16%) had a moderate ability to choose strategies to solve problems, 0 students (0%) had a low ability to choose strategies to solve problems and 40 students (40%) had a very low ability to choose strategies to solve problems. When viewed from the results of the analysis, it appears that many students are still unable to choose and use strategies in problem solving. This is in line with the results of research by Jaenudin et al (2025) and Novriani & Surya (2017) which found that students have difficulty in planning and implementing strategies in solving problems. The following are the results of the work and interviews of researchers (R) with students who have a high ability to choose strategies to solve problems (subject 83 (S 83))



Subject 83 (S 83)

5. a. The time required is 45 minutes.
b. 06.45-06.45 = 45

Translation of subject 83's answer

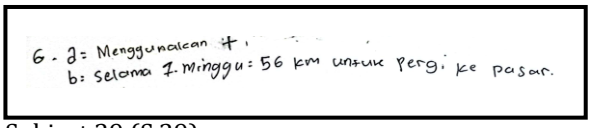
R : How do you calculate Badu's travel time from home to school?
S 83 : I subtracted the time Badu arrived at school from the time he left.
R : What time did Badu leave?
S 83 : 6:00 AM, Sir.
R : What time did Badu arrive at school?
S 83 : 6:45 AM, Sir.
R : How do you determine the travel time?
S 83 : 6:45 AM - 6:00 AM, Sir.
R : Look at your answer sheet!
S 83 : (Pause and think) Yes, sir, I wrote it wrong.

Based on the results of student work and interview results, it can be concluded that subject 83 has the ability to choose and use strategies in solving problems well, this is seen from S 83's answer when using the strategy of subtracting the time until Badu arrives at school from the departure time. S 83 was also able to state that the travel time was 06:45 minus 06:00. However, on S 83's test result sheet it was written 06:45 - 06:45, this happened because S 83 was not careful in writing it. This is in line with the findings of several studies that lack of carelessness and carelessness are the causes of errors made by students (Herawati & Marfuah, 2021; Najah & Jamaluddin, 2024; Rusdianti & Masriyah, 2021;).

Ability to Use Symbolic, Formal, and Technical Language and Operations

Based on the results of the analysis of the indicators of the ability to use symbolic, formal, and technical language and operations, from 100 students who took the test, the following details were obtained, as many as 20 students (20%) had very high abilities to use symbolic, formal, and technical language and operations, 4 students (4%) had high abilities to use symbolic, formal, and technical language and operations, 28 students (28%) had the ability to use symbolic, formal, and technical language and operations, 0 students (0%) had low abilities to use symbolic, formal, and technical

language and operations and 48 students (48%) had very low abilities to use symbolic, formal, and technical language and operations. The following are the results of the researcher's (R) work and interviews with students who have high ability to choose strategies to solve problems (subject 39 (S 39))



Subject 39 (S 39)

6. a. using +
b. 1 week = 56 km to the market

Translation of subject 39's answer

R : What mathematical operation would you use to calculate the total distance Nani traveled in a day?
S 39 : Using addition, sir.
R : What are you adding?
S 39 : The distance from the market to the market, sir
R : How would you write it?
S 39 : 4 + 4, Sir?
R : How would you answer part b?
S 39 : 56 km
R : Where do you get 56 km?
S 39 : Since it's a week, sir, so 8 times 7 is 56 km.

Based on the student's work and interview results, it can be concluded that subject 39 has quite good abilities in using symbolic, formal, and technical language and operations. S 39 was able to provide clear verbal answers. However, on S 39's test results sheet, the answers to questions 6a and 6b were still very limited, so they were unable to provide clear information to the reader. In section 6a, S 39 only wrote the answer using +, when what should have been written was 4 + 4. S 39 did the same when answering section 6b, S 39 immediately answered 56 km without writing the mathematical process. There needs to be emphasis on students regarding the process of working on questions, which is certainly more important than the final result (Basri et al., 2021; Damni & Reflina, 2023; Kusuma et al., 2018).

LIMITATION

This study has several limitations that should be acknowledged. First, the research employed a qualitative descriptive approach with a limited number of schools and participants, which constrains the generalizability of the findings beyond Region III Cirebon. Second, the analysis relied primarily on test and interview data, without incorporating classroom observations or teacher perspectives that might have provided a richer contextual understanding of the factors influencing students' numeracy literacy development. Third, the assessment instrument—although constructed based on Windisch's (2015) six-indicator framework—has not yet undergone extensive empirical validation across diverse educational settings, which may have introduced potential bias in data interpretation. Finally, this study was limited to identifying and describing students' numeracy literacy levels; it did not examine the impact of specific instructional interventions or learning strategies aimed at enhancing these competencies.

Given these limitations, future research is encouraged to employ mixed-methods or longitudinal designs involving larger and more diverse samples to strengthen the external validity of the findings. Subsequent studies could also integrate teacher training and curriculum design components to explore how instructional practices influence numeracy literacy outcomes. Moreover, the development and validation of standardized instruments for assessing numeracy literacy across educational levels would provide a more robust foundation for comparative studies. By addressing these aspects, future research can contribute to a more comprehensive understanding of how to foster numeracy literacy effectively in elementary education and beyond.

CONCLUSION

Based on the results of the research and discussion described regarding the numeracy literacy skills of fifth-grade elementary school students in Region III Cirebon, it shows that students' numeracy literacy skills are in the medium category tending to be low. Of the six numeracy literacy indicators analyzed, only the communication ability indicator is in the high category. Three indicators of numeracy literacy skills are in the medium category, namely representation ability, reasoning and argumentation ability and the ability to choose strategies to solve problems. While the other two indicators, namely mathematization ability and the ability to use symbolic, formal and technical language and operations are in the low category. Some of the causes of students' failure to meet these indicators include: (1) students' incomplete understanding of concepts, (2) students have not been able to express fractions using mathematical symbols correctly, (3) students are less careful and careless in writing answers and (4) students tend to write the final results without a clear thought process. The results of this study are expected to be recommendations for further research in developing learning designs or learning media designs in order to improve students' numeracy literacy skills.

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