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Assessing Junior High School Students' Numeracy Literacy in Solving Statistical Problems: A Case Study in Sumedang Regency

Siti Sundari[1], Lia Yuliawati[2], Neneng Tita Rosita[3], M. Nuur'aini Sholihat[4]
[1,2,3,4]Universitas Sebelas April, Sumedang, Indonesia

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ABSTRACT

This study aims to determine the numeracy literacy level of 8th-grade students at SMP Negeri 9 Sumedang, considering the ongoing challenges in students' ability to interpret, analyze, and solve statistical problems. Many students struggle with numeracy literacy, affecting their ability to make data-driven decisions, which influences their academic achievement, financial literacy, and future employability. This research employs a descriptive qualitative method involving 31 eighth-grade students selected through purposive sampling. Data collection includes students' numeracy literacy test results on statistical material, interviews, and document analysis. Data analysis follows three stages: data reduction, presentation, and verification. The results indicate that students' numeracy literacy remains low, with an average test score of 29.3, and only 16% meet the minimum competency level in statistical reasoning. Interviews with two representative students revealed significant difficulties in understanding statistical concepts, particularly in interpreting data from tables and graphs, identifying relevant information for problem-solving, and applying appropriate mathematical strategies. Additionally, students struggled with structuring solutions systematically and drawing meaningful conclusions from statistical data. The primary factors contributing to this low performance include (1) students' reluctance to engage with lengthy word problems, (2) lack of understanding of prerequisite materials, and (3) difficulties in determining problem-solving strategies. These findings highlight the need for improved instructional strategies to enhance students' statistical reasoning and numeracy literacy. Future research should explore intervention programs that strengthen students' ability to interpret and apply statistical data in real-world contexts. These findings can help educators design more effective teaching strategies and assist policymakers in developing numeracy-focused curricula that better prepare students for future challenges.

Corresponding Author:

Lia Yuliawati
FKIP Universitas Sebelas April, Sumedang, Indonesia
Email: yuliawati_fkip@unsap.ac.id

1. INTRODUCTION

Education plays a fundamental role in shaping the quality of a nation's human resources. One essential education component is numeracy literacy, which refers to the ability to understand, use, and interpret numbers and data in various real-life contexts [1], [2]. Numeracy literacy is essential for academic success and plays a significant role in decision-making processes in everyday life, such as financial planning, interpreting statistical reports, and problem-solving [3]. However, Indonesian students continue to face challenges in numeracy literacy despite its importance. Low numeracy literacy among Indonesian students remains a concern, as shown in the 2024 Indonesian Education Report, where only 65% of middle school students meet the minimum competency standards (kemdikbud). This issue is not limited to academic performance but also affects students' ability to engage with financial literacy, economic reasoning, and workforce readiness [4]. The OECD [4] reports that countries with stronger numeracy literacy rates experience higher economic stability and workforce participation. Similarly, PISA [5] findings highlight a direct correlation between students' numeracy skills and future employability, emphasizing the importance of early numeracy intervention in national education policies.

Many studies have explored the challenges students face in numeracy literacy, with one of the most persistent issues being difficulty understanding and interpreting statistical data presented in tables, graphs, and real-world problems [6], [7]. Additionally, students often rely on memorizing formulas rather than developing a conceptual understanding, which prevents them from effectively applying mathematical reasoning to problem-solving tasks [8]. Research also indicates that students struggle with structuring solutions, selecting appropriate problem-solving strategies, and evaluating their reasoning, leading to errors in applying statistical concepts [9]. These difficulties highlight the limitations of traditional teaching methods, which tend to emphasize procedural calculations without fostering deeper conceptual understanding or real-world applications [10].

Several teaching strategies have been proposed to address these issues. Among them, Problem-Based Learning (PBL) has gained attention for its potential to engage students in real-life problem-solving, encouraging them to analyze and interpret data meaningfully [9]. Another promising approach is ethnomathematics-based learning, which integrates cultural elements into statistical concepts, making mathematical reasoning more relevant and contextualized for students [11]. Additionally, the use of digital tools such as GeoGebra, integrated into the Think-Talk-Write (TTW) model, has been shown to significantly improve students' ability to visualize and interpret statistical data, making learning more interactive and effective [6], [12]. Despite the success of these approaches, most existing research focuses on conceptual and procedural aspects of numeracy literacy rather than exploring how students interpret and apply statistical data in decision-making scenarios [6], [13]. Many studies emphasize computational skills but lack an in-depth investigation into how students analyze, interpret, and utilize numerical data in real-life contexts. Given the growing importance of statistical literacy in modern society, further research is needed to explore middle school student's ability to interpret and apply statistical information effectively.

Numeracy literacy is deeply connected to cognitive development and problem-solving skills. Piaget's cognitive development theory suggests that students at the formal operational stage (ages 11–15) should be able to engage in logical reasoning and abstract thought [14]. However, many middle school students struggle with higher-order mathematical thinking, particularly in real-world statistical applications [15]. This suggests that while they have the cognitive capacity for statistical reasoning, they may lack effective instructional approaches to develop these skills. Vygotsky's constructivist theory emphasizes that learning is most effective when students interact with their environment and peers [16]. This supports the implementation of contextual learning strategies, such as ethnomathematics and problem-based learning, which have been shown to enhance students' ability to interpret and apply statistical data in meaningful ways [9], [11].

Previous studies on numeracy literacy have examined arithmetic proficiency and statistical problem-solving [1], [7]. While research has explored students' ability to analyze statistical data, most studies have focused on computational accuracy rather than interpretative reasoning [2], [10]. Additionally, studies on technology-based interventions, such as GeoGebra, have largely focused on algebraic problem-solving rather than statistical reasoning [12]. While Problem-Based Learning (PBL) has enhanced mathematical problem-solving skills, its impact on students' ability to use statistical reasoning for real-world decision-making remains underexplored [9]. Unlike previous studies focusing on students' ability to compute statistical measures, this research investigates how middle school students interpret and apply statistical reasoning in authentic problem-solving scenarios. While prior research has established the importance of statistical literacy, few studies have examined how students transition from computational proficiency to meaningful data interpretation and real-world decision-making. This study aims to bridge this gap by providing empirical insights into students' reasoning processes using statistical data.

To address these challenges, this study employs a qualitative descriptive method to explore the effectiveness of contextual learning and digital technology integration in numeracy literacy development. Through classroom observations and student problem-solving analysis, this research aims to identify instructional strategies that enhance students' ability to interpret and apply statistical concepts in decision-making contexts.

This study explores middle school students' numeracy literacy skills in solving statistical problems. Specifically, it seeks to (1) identify common errors students make, (2) examine factors influencing their understanding of statistics, and (3) propose effective instructional strategies to enhance their numeracy literacy. This study aims to bridge the gap between theoretical mathematical knowledge and practical problem-solving skills by integrating contextual learning, digital tools, and real-world data applications.

Findings from this research will contribute to curriculum development, instructional material design, and teacher training programs aimed at improving numeracy literacy in Indonesia. More importantly, the insights gained will support the development of national assessment frameworks that move beyond procedural fluency to assess students' ability to interpret and apply statistical data. By addressing these critical gaps, this research has the potential to shape future education policies and enhance students' preparedness for a data-driven world.

2. METHOD

This study employs a qualitative descriptive method to explore and describe students' numeracy literacy skills in solving statistical problems. The qualitative descriptive approach was chosen because it allows for a detailed examination of students' problem-solving processes, thought patterns, and reasoning skills, which would be challenging to capture through purely quantitative methods. A mixed-method approach was considered; however, the study focuses more on the in-depth exploration of students' responses rather than statistical generalization, making qualitative descriptive methodology the most suitable choice.

The study was conducted at SMP Negeri 9 Sumedang, with a research population of 190 eighth-grade students. The sample was selected using purposive sampling, specifically Class VIII-A, consisting of 31 students. The selection criteria were carefully determined to ensure representativeness and alignment with the study's objectives: (1) students who have already studied statistics in their curriculum; (2) students who can clearly articulate their thoughts, both orally and in writing, ensuring a deeper qualitative analysis; and (3) students with diverse mathematical abilities categorized as excellent, good, fair, and poor, to reflect a range of numeracy literacy levels. The choice of Class VIII-A was based on consultation with teachers, ensuring that the sample includes a balanced mix of mathematical abilities while maintaining manageable data collection for qualitative analysis. This sample, while not randomly selected, is representative of the broader student population at the school in terms of academic performance and background diversity.

The numeracy literacy indicators used in this study were adapted from Han et al. [1] and refined to align with recognized educational assessment frameworks, such as PISA (Programme for International Student Assessment) and OECD's numeracy proficiency model. The indicators include (N1) the ability to use various numbers and symbols related to algebraic operations, (N2) the ability to analyze information effectively, and (N3) the ability to interpret analysis results to make predictions and informed decisions. Accordingly, the numeracy literacy indicators applied to the given statistical problems are: (N1) writing numbers and symbols related to data analysis, including data distribution, mean, median, mode, and data spread, to conclude, make decisions, and formulate predictions accurately and comprehensively; (N2) identifying and writing relevant data from the provided tables, as well as clearly stating what is being asked; and (N3) solving the given problems and explaining the results or conclusions correctly and accurately. These indicators were reviewed against existing mathematical literacy rubrics to ensure alignment with standardized assessment frameworks, ensuring the study measures constructs relevant to internationally recognized numeracy skills. Referring to Arikunto [17], the assessment criteria for students' numeracy literacy skills were determined based on these indicators.

Table 1. Criteria of Students' Numeracy Literacy Skill Results

Interval Score	Criteria
76 ≤ score ≤ 100	Excellent
51 ≤ score ≤ 75	Good
26 ≤ score ≤ 50	Fair
0 < score ≤ 25	Low

Multiple data sources were utilized to comprehensively assess students' numeracy literacy: written tests, interviews, and document analysis. The test consisted of three open-ended questions designed to evaluate numeracy literacy based on statistical problem-solving scenarios. Subject matter experts reviewed the test to ensure content validity and clarity. To ensure reliability, the test was piloted with a different group of students before the actual study. The responses were evaluated using an inter-rater reliability check, where multiple assessors scored the test responses independently. A high level of agreement was obtained, confirming consistency in assessment. Semi-structured interviews were conducted with selected students to explore their reasoning processes, thought patterns, and problem-solving strategies in-depth. Students' written responses were analyzed qualitatively to identify common errors, reasoning structures, and levels of numeracy literacy. For validity, the test was reviewed by mathematics education experts to ensure alignment with standard numeracy literacy frameworks. Additionally, triangulation was applied by comparing data from test results, interviews, and document analysis to enhance credibility.

The test used in this study was designed to assess students' numeracy literacy skills through three open-ended questions (Test 1, Test 2, and Test 3). In Test 1, students were given a problem that required them to determine the average number of people living in poverty over six-month periods from March 2013 to March 2015. This calculation was based on a poverty data graph from 2020, which was presented in the form of an illustration.

Figure 1. Statistical data in Test 1: Poverty profile in Indonesia, recorded every six months from March 2013 to September 2020 [18]

Based on the information provided in Figure 1, students' numeracy literacy skills are assessed using the following indicators: (N1) writing numerical data representing the population statistics from March 2013 to March 2015; (N2) identifying and writing down the given data from the provided image and clearly stating what is being asked; and (N3) solving the problem and explaining the results or conclusions accurately and correctly.

In Test 2, students are given a statistical problem related to technology usage, particularly mobile phones. The problem is presented in the following case:

"Maria received a new mobile phone as a gift from her father. She wants to continue using her old phone but needs to delete two apps with the highest average battery usage. These two apps will then be installed on the new phone. The order of battery usage, from highest to lowest, is TL, YT, IG, and WA. Consider the following statements: A) *Maria will delete IG from her old phone;* B) *Maria will delete TL from her old phone;* C) *YT will be installed on the new phone; and* D) *Maria will delete WA from her old phone. Determine which statements are correct and explain your reasoning!"*

Through this problem, students are expected to demonstrate their abilities in (N1) identifying and analyzing symbols representing the two apps with the highest average battery usage; (N2) extracting relevant data from the given image and clearly stating what is being asked; (N3) determining which apps should be deleted from the old phone and which should be installed on the new phone, providing correct and well-reasoned answers.

The last is Test 3, where students must calculate the average percentage of the male open unemployment rate per year based on data from February 2016 to February 2020, as presented in the following figure.

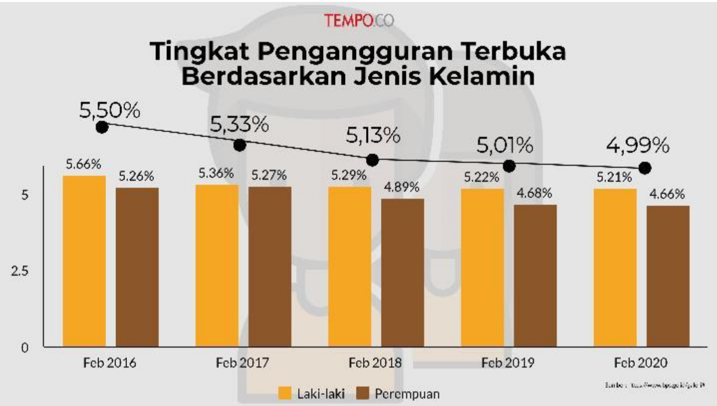

Figure 2. Statistical data in Test 3: Open Unemployment Rate by Gender [19]

The skills assessed in Test 3 include: (N1) writing numerical values that represent statistical data on male unemployment; (N2) identifying and recording the given data from the presented image and clearly stating the question being asked; and (N3) solving the problem and accurately explaining the results or conclusions.

The research was conducted in two stages: the preparation stage and the implementation stage. During the preparation stage, the researcher conducted observations and developed a test blueprint. In the implementation stage, data collection and data analysis were carried out. The data analysis in this study followed three main steps:

a. Data Reduction – Selecting and refining data from the literacy and numeracy test results related to statistical problems.
b. Data Presentation – Describing students' numeracy literacy skills based on their process of completing the test, aligned with the established indicators.
c. Conclusion Drawing – Summarising findings based on the analyzed data and presenting them in a descriptive format.

3. RESULTS AND DISCUSSION

The research results show that the average numeracy literacy test score of the 31 students was 29.3, which falls into the "low" category. The number of students in each category is presented in Figure 3 below. The data in Figure 3 indicate that 26 out of 31 students were in the "low" numeracy literacy category. In other words, 84% of the students had low numeracy literacy skills in solving statistical problems.

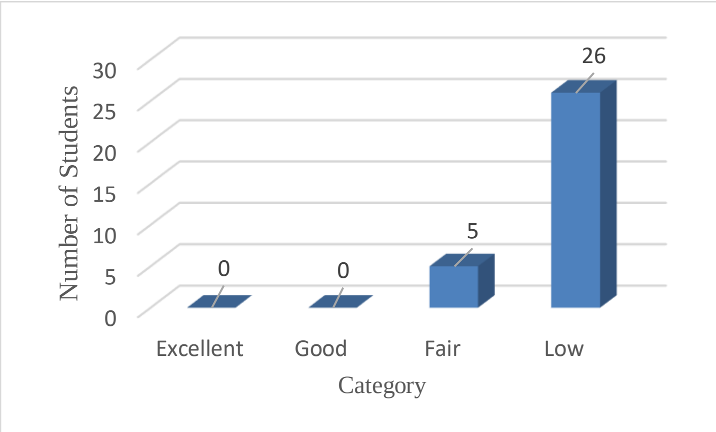

Figure 3. Numeracy Literacy Skills Test Score Data

The table below presents the percentage of students who answered each question correctly and accurately for each indicator.

Table 2. Percentage of Students Who Answered Correctly and Accurately for Each Indicator

Indicator (N)	Test 1	Test 2	Test 3
N1	71%	16%	10%
N2	45%	13%	10%
N3	42%	10%	10%

Table 2 shows that none of the students could meet all three numeracy literacy indicators when solving statistical problems. For the first numeracy literacy indicator (N1)—which involves using various numbers and symbols to analyze data distributions, mean, median, mode, and data spread to conclude, make decisions, and predict outcomes—the highest percentage of achievement (71%) was found in question 1, meaning that 22 students met this indicator. However, for questions 2 and 3, the percentage dropped significantly to 16% and 10%, respectively. This finding highlights a key issue: while many students could write numbers and symbols related to data analysis (such as calculating the mean, median, and mode), they struggled to apply these numbers effectively in the problem-solving process. For the second numeracy literacy indicator (N2)—which measures students' ability to extract relevant data from a table and identify what is being asked—the percentage of students who met this criterion was 45% (14 students) for test 1, 13% (4 students) for test 2, and only 10% (3 students) for test 3. These results suggest that students struggle to interpret statistical information presented in a given problem. For the third numeracy literacy indicator (N3)—which involves interpreting analysis results to make predictions and decisions—the lowest achievement percentage was in question 3, at just 10%. This was mainly due to calculation errors and incomplete conclusions. Many students failed to provide a conclusion for their written solutions.

In summary, students who were able to use numbers and symbols to analyze data distributions, calculate statistical measures, and identify key information from a problem did not necessarily have strong numeracy literacy skills. A student’s numeracy literacy can only be considered strong if they successfully meet all three indicators. Based on test results and interviews, the researcher analyzed two sample students representing different numeracy literacy levels: (S1) a student with a “fair” level of numeracy literacy and (S2) a student with a “low” level of numeracy literacy.

3.1. Students' Abilities with “Fair” Level Numeracy Literacy (S1)

Please see the results of the following student answers below**:**

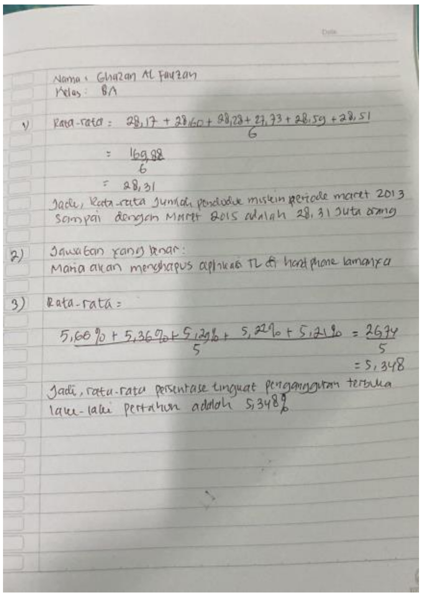

Figure 4. Responses of Students with Moderate Numeracy Literacy Skills

For S1, out of the three given questions, the student could answer one correctly and accurately, while the other two were partially incorrect. During the interview, S1 identified question 2 as the most difficult. Although S1 understood the question, they made a mistake in their response by selecting only one correct statement without considering that multiple statements could be correct. S1 admitted that they chose the right statement without thoroughly evaluating other possible correct answers.

On the other hand, S1 found questions 1 and 3 easier. However, despite considering question 1 easy, S1 failed to state the statistical data on population numbers from March 2013 to March 2015. The students focused only on the information that the data in the graph presented every six months, leading them to mistakenly assume that they only needed to calculate the average for six months. Meanwhile, for question 3, S1 was able to understand and explain the solution correctly. When asked to choose between solving a word problem or a direct numerical problem, S1 preferred the direct numerical problem, stating:

"I do not like reading long questions; they confuse me, and I would probably misunderstand the problem."

3.2. Students' Abilities with "Low" Level Numeracy Literacy (S2)

Please see the results of the following student answers below**:**

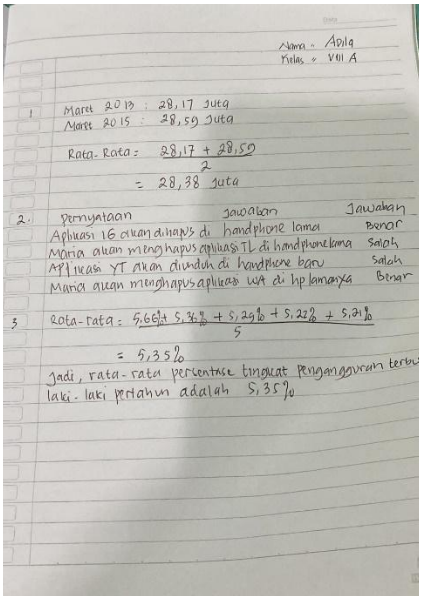

Figure 5. Responses of Students with Intermediate Numeracy Literacy Skills

S2 could answer one correctly and accurately from the three open-ended questions, while the others were incorrect. Based on the interview results, S2 struggled with understanding and solving questions 1 and 2. For question 3, S2's final answer was correct; however, when asked to explain and elaborate on their reasoning, S2 made calculation errors and did not consider the required period. S2 admitted to not fully understanding the concept of averages over a given time span and how to calculate them, leading to an answer that was based on a single data point rather than an overall average.

For question 1, S2's response was incorrect. During the interview, S2 stated that they did not understand how to approach the question, misinterpreted the information in the table, and felt overwhelmed by the amount of information presented. Interestingly, S2 considered question 1 to be the easiest. However, explaining their approach made it clear that S2 misunderstood the averaging concept over time. They incorrectly calculated the average by only considering two specific points—March 2013 and March 2015—rather than using the full dataset. When given the option to choose between solving a word problem or a direct numerical problem, S2 preferred the direct numerical problem, stating: "Word problems are too long and confusing, making it hard to know where to start. With direct numerical problems, I already know what needs to be calculated."

Based on the above observations, the study revealed several key findings about students' numeracy literacy. Regarding the first indicator, many students could write numbers and statistical symbols, such as calculating averages. However, a significant number still struggled to use these numbers effectively to draw conclusions or make accurate decisions. The students' responses demonstrated that while they could perform basic calculations, they often failed to properly interpret information presented in images, tables, or word problems. Some students even stopped at numerical computations without progressing to problem-solving or drawing meaningful interpretations.

This study supports findings from previous research by [10] and [20], which indicated that many students follow computational procedures mechanically without genuinely understanding how data can be applied in real-world contexts. Their research highlighted that students memorize calculation steps rather than grasp the data distribution concept and its relationship to statistical problem-solving [10], [18].

The second indicator examined in this study was students' ability to extract and interpret relevant data from given problems. The results showed that while most students could copy numbers from the provided tables, not all could identify which data was relevant for calculations. Some responses indicated that students only used partial data, leading to calculations not representing the overall information provided. Additionally, some students randomly listed numbers without understanding how those figures related to the problem. Many students struggled with reading tables and graphs, which often led them to use incorrect information in their calculations, directly impacting the accuracy of their final answers [2]. Furthermore, some students failed to write the full problem statement before starting their calculations, causing their problem-solving steps to deviate from the intended requirements [2].

The final indicator analyzed in this study was how well students structured their solutions and formulated accurate conclusions. While many students followed correct procedural steps, most did not provide sufficient explanations or conclusions regarding their results. In several cases, students wrote down numerical answers without interpreting their significance concerning the problem. Students focusing solely on obtaining answers without explaining their reasoning tend to struggle with analytical numeracy problems [21]. Additionally, some students skipped crucial steps in their calculations, making it difficult to understand their thought processes. The inability to systematically organize solutions often leads to errors in final answers [22]. Therefore, further training is necessary to help students develop structured and logical problem-solving approaches [19], [20].

A deeper analysis reveals multiple cognitive and pedagogical factors contributing to students' struggles with numeracy literacy. Many students were able to perform basic calculations but struggled to interpret statistical data in a meaningful way. This aligns with prior research indicating that Indonesian students often follow procedural steps without conceptualizing data representation and its application to decision-making [1]. A lack of comprehension regarding problem statements often leads students to apply incorrect problem-solving strategies, causing them to misinterpret the required analysis method or fail to consider key aspects of the given data [23]. Many students rely on memorizing formulas without understanding how their calculations can inform decision-making, as seen in cases where they could compute an average but could not explain whether the result accurately represented the data distribution [24]. Furthermore, students frequently focused solely on numerical results without considering how those values could be used to make predictions or decisions in real-world scenarios [25].

Additionally, this study found that a lack of argumentation skills in statistical problem-solving posed a major challenge for students. Many provided final answers without justifying or interpreting their responses. Poor mathematical argumentation skills in statistics stem from learning methods prioritizing procedural calculations over conceptual exploration and verbal justification [26]. Students also struggled with symbolic and verbal representations in mathematics, which hindered their ability to effectively explain statistical problem-solving processes [10], [24].

Numeracy literacy skills are closely tied to problem-solving abilities, and one of the major factors contributing to students' struggles in statistics is a lack of motivation to learn. Low learning motivation has been identified as a primary cause of weak statistical problem-solving skills [18]. However, this study suggests that conceptual misunderstandings, rather than motivation, play a more significant role in students' difficulties. Students were more engaged with statistical problems when the material was linked to familiar, real-life contexts, demonstrating that the relevance of content can significantly impact learning outcomes [18], [27].

A more exploratory and concept-based learning approach is needed to address these challenges. Teachers should provide more exercises that require students to interpret their calculations in real-world scenarios, such as analyzing population trends or comparing product prices over time [20]. Additionally, improving students' ability to understand mathematical texts is crucial, as practicing reading and interpreting tables and graphs before performing calculations can help students differentiate relevant data from extraneous information [23]. Teachers can facilitate this process by asking guiding questions like: "What information is provided in the table?" or "How does this data relate to the question being asked?" [23].

Another effective approach is encouraging students to verbalize their thought processes while solving problems. The think-aloud method, where students explain each step verbally before writing it down, can help reinforce their understanding [21]. Additionally, requiring students to interpret their answers in complete sentences rather than simply providing numerical solutions helps build stronger analytical reasoning skills [23].

The results align with international studies on numeracy literacy gaps. For example, a study on PISA performance in Southeast Asia [5] found that Indonesian students often struggle with interpreting statistical data due to limited exposure to real-world mathematical applications. Similar findings in Malaysia and the Philippines indicate that students in the region face challenges in analyzing and drawing conclusions from statistical information [28], [29]. Studies in Thailand further confirm that students have difficulty linking statistical concepts to practical applications, emphasizing the need for improved instructional methods [30]. However, some differences emerge when comparing these results with studies in countries with strong numeracy literacy performance. Research in Finland and Singapore suggests that early exposure to data analysis through hands-on projects helps students develop better reasoning skills [31], [32]. Additionally, studies in Australia have shown that integrating statistical literacy within interdisciplinary contexts fosters better comprehension [33]. This underscores the need for a shift in pedagogical approaches in Indonesian schools.

This study, along with previous research, highlights students' difficulties in interpreting statistical data, their weak argumentation skills in problem-solving, and the need for more context-based learning approaches. By integrating proven strategies from existing literature, students can be better prepared to handle numeracy challenges in real-world scenarios and international assessments such as PISA [10], [24].

4. CONCLUSION

The findings of this study provide critical insights into the challenges faced by students in numeracy literacy, particularly in statistical problem-solving of eighth-grade students at SMP Negeri 9 Sumedang. The results indicate that most students struggle to extract relevant data, interpret statistical information, and draw logical conclusions, reflecting broader issues in numeracy education. While students exhibit basic computational skills, their conceptual understanding of statistical reasoning remains weak due to instructional approaches emphasizing rote memorization over deep comprehension.

This study contributes to improving numeracy literacy education by highlighting the need for curriculum adjustments that prioritize conceptual understanding and real-world applications of statistical reasoning. Specifically, integrating context-based learning, such as using real datasets in teaching statistics, can help students develop stronger analytical skills. Furthermore, interactive teaching strategies, including think-aloud exercises, structured problem-solving discussions, and argumentation-based mathematics learning, can enhance students' ability to reason with data.

From a policy perspective, education stakeholders should consider revising assessment methods to focus on open-ended problem-solving and data interpretation rather than multiple-choice formats. Additionally, professional development programs for teachers should emphasize instructional strategies that promote critical thinking in statistics, moving beyond procedural exercises to encourage deeper engagement with mathematical concepts. However, this study has certain limitations. The sample size was relatively small, consisting of only 31 students, which may limit the generalizability of the findings. Future research should involve more diverse samples to validate these results across educational settings. Moreover, this study primarily relied on test scores and interviews; incorporating classroom observations and longitudinal studies could provide deeper insights into students’ learning processes and the effectiveness of different teaching interventions. Addressing these limitations and implementing the recommended curriculum adjustments can significantly improve numeracy literacy education, equipping students with the analytical skills to effectively interpret and utilize statistical data in academic and real-world contexts.

Future research is expected to develop instructional designs or learning media to help students become more accustomed to calculations and apply their numeracy literacy skills in everyday life. Additionally, it is recommended that future studies explore higher education levels, refine test instruments, and expand assessments to other mathematical topics such as geometry and algebra.

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