SJME (Supremum Journal of Mathematics Education)
Vol.10, No.2, Juli 2026, pp. 263-275
ISSN: 2548-8163 (online)| ISSN: 2549-3639 (print)
DOI: 10.35706/sjme.v10i2.13415

When Context Meets Numbers: Exploring Junior High School Students' Numeracy Performance in Real-World Problems

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Article Information
Received April 20th, 2026
Revised June 29th, 2026
Accepted July 13th, 2026

Diterima 20 April 2026
Direvisi 29 Juni 2026
Disetujui 13 Juli 2026

Keywords:
Numeracy Skills; Formulate; Employ; Interpret

Kata kunci:
Kemampuan Numerasi; Formulate; Employ; Interpret

ABSTRACT

Students' numeracy skills in Indonesia are expected to support contextual problem-solving and higher-order thinking. However, international assessment results indicate that Indonesian students' numeracy skills remain low and have not yet met expected standards, as reflected in the 2022 PISA results, in which Indonesia obtained an average mathematics score of 366 points, far below the OECD average of 472 points. This study analyzed junior high school students' numeracy skills based on three indicators: Formulate (F), Employ (E), and Interpret (I). A quantitative descriptive approach was used with 32 junior high school students selected through purposive sampling. Data were collected using a written test consisting of six items with a maximum score of 72 points and were supplemented by semi-structured interviews with three students purposively selected to represent the moderate, low, and very low achievement categories. The interviews explored students' reasoning processes in solving the numeracy tasks. The results showed that students' average numeracy score was 30.34%, placing it in the Low category. No students reached the High or Very High categories, and 56.25% of students were in the Low category. Indicator analysis showed a declining pattern from Formulate (38.92%) to Employ (32.08%) and Interpret (29.00%). Item 1a had the highest achievement (93.75%), whereas item 2c was not answered successfully by any student (0.00%). These findings indicate the need to improve authentic context-based learning that requires higher-order thinking skills at the junior high school level.

ABSTRAK

Kemampuan numerasi siswa di Indonesia diharapkan mampu mendukung pemecahan masalah kontekstual dan berpikir tingkat tinggi. Namun, hasil penilaian internasional menunjukkan bahwa kemampuan numerasi siswa Indonesia masih berada pada kategori rendah dan belum memenuhi standar yang diharapkan, sebagaimana tercermin dalam hasil PISA 2022, di mana Indonesia memperoleh skor rata-rata 366 poin dalam matematika, jauh di bawah rata-rata OECD sebesar 472 poin. Penelitian ini bertujuan menganalisis kemampuan numerasi siswa SMP berdasarkan tiga indikator, yaitu Formulate (F), Employ (E), dan Interpret (I). Penelitian ini menggunakan pendekatan deskriptif kuantitatif dengan melibatkan 32 siswa SMP yang dipilih melalui purposive sampling. Data dikumpulkan melalui tes tertulis yang terdiri atas enam soal dengan skor maksimum 72 poin dan dilengkapi wawancara semi-terstruktur

terhadap tiga siswa yang dipilih secara purposif untuk mewakili kategori pencapaian sedang, rendah, dan sangat rendah. Wawancara bertujuan mengeksplorasi proses penalaran siswa dalam menyelesaikan tugas numerasi. Hasil penelitian menunjukkan bahwa rata-rata kemampuan numerasi siswa sebesar 30,34%, termasuk kategori Rendah. Tidak ada siswa yang mencapai kategori Tinggi atau Sangat Tinggi, dan 56,25% siswa berada pada kategori Rendah. Analisis per indikator menunjukkan pola penurunan dari Formulate (38,92%) ke Employ (32,08%) dan Interpret (29,00%). Soal 1a memiliki pencapaian tertinggi (93,75%), sedangkan soal 2c tidak berhasil dijawab oleh satu pun siswa (0,00%). Temuan ini mengindikasikan perlunya peningkatan pembelajaran berbasis konteks autentik yang menuntut kemampuan berpikir tingkat tinggi di tingkat SMP.

INTRODUCTION

Numeracy is an essential foundational skill for every individual in navigating the challenges of life in the 21st century. Numeracy is not merely the ability to perform calculations; rather, it encompasses the ability to understand, apply, and reason with mathematical concepts in increasingly complex real-life contexts (OECD, 2023b; Umbara & Suryado, 2019). In the context of Indonesian education, numeracy skills constitute one of the key domains assessed in the Minimum Competency Assessment (AKM) as part of the national education assessment reform policy (Hidayah et al., 2021; Purnomo et al., 2022).

The importance of numeracy skills for junior high school students is also reflected in various international studies that consistently reveal a concerning situation (Sa'dijah et al., 2023; Nuryami, 2024). According to the 2022 Programme for International Student Assessment (PISA) results, Indonesia achieved an average mathematics score of 366 points, well below the OECD member-country average of 472 points (OECD, 2023b). Efforts to develop contextual PISA-based tasks as educational interventions have been explored by researchers to improve students' numeracy skills, including the development of jumping-based PISA tasks (Nusantara, Ibarra, et al., 2025). Such task designs aim to create engaging and meaningful learning experiences that support the development of numeracy skills in authentic contexts. Similar findings were also reported in the 2019 Trends in International Mathematics and Science Study (TIMSS), in which Indonesian students ranked 44th out of 46 participating countries at the eighth-grade level (Kusumaningtyas, 2020). These low scores indicate that fundamental problems remain in Indonesian students' numeracy skills (Rakhmawati & Mustadi, 2022). Overall, the results of these international assessments indicate that Indonesian students' numeracy skills remain in the low category and have not yet met the expected standards.

Various national studies also corroborate these international findings. Setianingsih and Ekayanti (2022) found that junior high school students' numeracy skills in solving AKM-type problems generally remain at the basic competency level, with the most prominent weakness occurring in mathematical reasoning. Students' difficulties in solving context-based numeracy problems have also been thoroughly identified by Wijaya et al. (2014). Their study revealed that Indonesian students face difficulties during the

transformation stage, that is, the process of converting contextual problems into appropriate mathematical models. Subsequent research has developed specialized PISA-like mathematics problems to better understand and address these transformation challenges. Examples include the development of PISA-like mathematics problems in various contexts, such as during the COVID-19 pandemic (Nusantara et al., 2020), as well as problems focusing on change and relationships (Nusantara et al., 2021). These task designs provide valuable frameworks for assessing and diagnosing specific areas in which students struggle during the problem-solving process. This finding is reinforced by Nusantara et al. (2021), who explained that many students tend to rely solely on procedural approaches without understanding the context of the problems presented. This situation indicates a gap between the procedural skills students have mastered and the application and reasoning skills required by numeracy problems.

To analyze numeracy skills comprehensively and systematically, this study uses three main numeracy indicators: Formulate, Employ, and Interpret (OECD, 2023a). This study aims to describe junior high school students' numeracy skills based on written test results analyzed quantitatively by indicator and by test item, supplemented by interview data to gain a deeper understanding of students' thought processes. The novelty of this study lies in the use of intra-item profiling techniques, an analytical approach that examines the Formulate–Employ–Interpret score pattern within each individual test item, in contrast to conventional item-by-indicator analysis, which aggregates indicator scores separately across items. This approach enables simultaneous analysis of the decline in numeracy performance from F to E to I within each test item and the identification of critical zero-achievement points, namely test items on which none of the 32 students obtained any score on one or more indicators. These critical points in complex contextual questions describe the cognitive threshold of junior high school students' numeracy skills regarding number concepts. The results of this study are expected to provide meaningful empirical contributions as a basis for developing more effective learning strategies and designs to improve junior high school students' numeracy skills, particularly in preparation for national and global assessment requirements.

METHOD

This study employed a quantitative descriptive approach to analyze junior high school students' numeracy skills (Creswell & Creswell, 2018). This approach was chosen because the study sought to describe the actual condition of students' numeracy skills based on written test scores without applying any intervention to the research subjects (Fauziah & Roza, 2022; Stacey & Turner, 2015). In this study, numeracy refers to an individual's ability to understand, apply, and reason with mathematical concepts to solve real-life problems (OECD, 2019).

The test instrument was developed based on numeracy ability indicators that encompass three main dimensions: Formulate, Employ, and Interpret. These three indicators were selected because they comprehensively measure students' numeracy abilities, ranging from basic understanding to higher-order reasoning, as shown in Table 1.

Table 1. Numeracy Skills Indicators (OECD, 2023a)

Indicator	Description
Formulate	The ability to understand the mathematical facts, concepts, and procedures needed to solve numeracy problems, including recalling information and classifying concepts.

Indicator	Description
Employ	The ability to apply knowledge and conceptual understanding to solve problems or answer questions, including more familiar and routine problems.
Interpret	The ability to engage in mathematical reasoning that goes beyond solving routine problems, encompassing unfamiliar situations, complex contexts, and multi-step problems that require higher-order thinking.

The subjects of this study were 32 junior high school students (A1 through A32). The research subjects were selected using purposive sampling, in which the sample is determined based on specific criteria tailored to the research objectives (Creswell & Creswell, 2018). These 32 students were selected because they were enrolled at the same grade level and had completed the curriculum content relevant to the numeracy test items, ensuring comparable prior knowledge while still reflecting the natural range of academic ability within one intact class. Thus, the resulting data could capture variation in numeracy performance from high to low achievers. The same numeracy test instrument was administered to all research subjects under uniform conditions and at the same time.

The instrument used in this study was an open-ended numeracy test consisting of six items: 1a, 1b, 1c, 2a, 2b, and 2c. Each item was designed to measure three indicators of numeracy skills: (1) Formulate (F), (2) Employ (E), and (3) Interpret (I). Each indicator for each item was scored on a scale of 0–4, resulting in a maximum total score of 72 (6 items × 3 indicators × 4 points). Items 1a–1c were developed around a single real-world context of a small trader's five-day sales record, requiring students to identify explicit information from a data table (item 1a), assess the consistency of sales figures (item 1b), and calculate net income through a multi-step operation involving revenue and costs (item 1c). Items 2a–2c extended this context into a more complex numeracy problem, requiring students to integrate several pieces of contextual information, complete a multi-step calculation, and produce a conclusion that was not explicitly stated in the given data, thereby placing higher cognitive demands on students' Formulate, Employ, and Interpret abilities.

Data were collected through a written test administered to all research subjects. The students' work was then graded using a predetermined rubric. The total score obtained by each student was converted into a percentage using the following formula:

$$\text{Percentage} = \frac{\text{Total Score}}{\text{Maximum Score}} \times \mathbf{100}\%$$

The percentage scores obtained were then categorized based on the numeracy criteria shown in Table 2.

Table 2. Criteria for Students' Numeracy Skills

Value (%)	Category	Number of Students
81 – 100	Very High	0
61 – 80	High	0
41 – 60	Moderate	8
21 – 40	Low	18
0 – 20	Very Low	6

Data analysis was conducted descriptively by calculating the percentage of students' numeracy skills both overall and for each indicator in every test item.

Quantitative descriptive analysis techniques were used to obtain a systematic and factual overview of students' numeracy skills (Sugiyono, 2019). In addition, each test item was analyzed to determine which items students mastered best and which items they found most difficult.

RESULTS AND DISCUSSION

Based on the results of the numeracy test administered to 32 junior high school students, a general picture emerged that students' overall numeracy skills were still relatively low. The average score achieved by all students was 30.34%, with the highest score of 54.17% achieved by Respondent A1 and the lowest score of 8.33% achieved by Respondent A3. No student reached the Very High or High category. The distribution of students' numeracy skills by category is presented in Table 3.

Table 3. Distribution of Students' Numeracy Skills by Category

Category	Range (%)	Number of Students	Percentage (%)
Very High	81 – 100	0	0.00
High	61 – 80	0	0.00
Moderate	41 – 60	8	25.00
Low	21 – 40	18	56.25
Very Low	0 – 20	6	18.75
Total	-	32	100

Based on Table 3, the majority of students fell into the Low category, totaling 18 students (56.25%), followed by the Moderate category with 8 students (25.00%) and the Very Low category with 6 students (18.75%). This indicates that the numeracy skills of the junior high school students who participated in this study generally had not developed optimally. This finding aligns with the results of PISA, which show that the mathematical literacy skills of Indonesian students, which are closely related to numeracy, remain below the international average; in PISA 2022, Indonesia obtained an average mathematics score of only 366 points, far below the OECD average of 472 points (OECD, 2023b).

To gain a deeper understanding, students' numeracy skills were also analyzed based on the specific indicators for each test item. The results of this analysis are presented in Table 4.

Table 4. Percentage of Students' Numeracy Skills by Indicator and Test Item

Question	F (%)	E (%)	I (%)	Mean	Ind. F	Ind. E	Ind. I
				Category			
1a	93.75	93.75	94.53	94.01	Very High	Very High	Very High
1b	10.16	0.78	19.53	10.16	Very Low	Very Low	Very Low
1c	76.56	46.88	32.03	51.82	High	Moderate	Low
2a	32.03	14.84	3.13	16.67	Low	Very Low	Very Low
2b	20.31	7.03	0.78	9.37	Very Low	Very Low	Very

Question	F (%)	E (%)	I (%)	Mean	Category	Ind. F	Ind. E	Ind. I
2c	0.00	0.00	0.00	0.00	Very Low	Very Low	Very Low	
Mean	38.92	32.08	29.00	30.34	Low	Low	Low	

Based on Table 4, a clear pattern emerged in students' numeracy skills. In Question 1a, students demonstrated excellent performance across all three indicators, with scores of 93.75% for Formulate, 93.75% for Employ, and 94.53% for Interpret, placing Question 1a in the Very High category. This indicates that the basic concepts tested in Question 1a were well understood by nearly all students.

Meanwhile, in Question 1c, performance declined, particularly in the Employ (46.88%) and Interpret (32.03%) indicators, although the Formulate indicator remained relatively high (76.56%). This pattern indicates that students were able to understand concepts procedurally but struggled when required to apply them and engage in further reasoning. Similar findings were reported by Safegi et al. (2021), who found that the greatest errors made by Indonesian students on PISA-type contextual questions occurred during the problem-transformation and reasoning stages, rather than in understanding basic concepts.

Student performance dropped drastically on questions requiring higher-order thinking. These items were categorized as higher-order because they required students to translate implicit verbal information into an appropriate mathematical model rather than extract explicit values directly, as in item 1a; integrate multiple pieces of data across more than one calculation step; and draw a conclusion that was not explicitly stated in the given data. In Question 1b, the Formulate percentage was only 10.16%, Employ was 0.78%, and Interpret was 19.53%, all of which fall into the Very Low category. A similar situation occurred in Questions 2a, 2b, and 2c, where nearly all students were unable to solve the questions. In fact, in Question 2c, not a single student scored any points (0% for all three indicators). These findings indicate that as the complexity of the questions increased, the difficulties faced by students also increased (Nawaz et al., 2022; Ferdianty et al., 2024).

Overall, the average achievement for the Formulate indicator was 38.92%, Employ was 32.08%, and Interpret was 29.00%, all of which fall into the Low category. This downward trend from Formulate to Employ and Interpret is consistent with the findings of Setianingsih et al. (2022) and Purnomo et al. (2023), who reported that junior high school students are generally not yet able to analyze information presented in various forms and remain at the basic competency level. The low level of Interpret ability, in particular, warrants serious attention because mathematical reasoning is a key competency required in both HOTS-based assessments and daily life. This pattern of declining performance from Formulate to Interpret is further corroborated by recent investigations into students' mathematical argumentation abilities in solving PISA-like mathematics tasks on change and relationships (Nusantara, Ilma, et al., 2025). That study similarly revealed significant limitations in higher-order reasoning, suggesting that the challenge of engaging in complex

mathematical reasoning extends across various problem types and mathematical domains. Table 5 shows the number of students who met each indicator partially (score > 0) and the number who achieved a perfect score (score = 4), indicating full mastery of the indicator. The results of the analysis are presented below.

Table 5. Number and Percentage of Students Meeting Each Indicator by Item

Question Number	Indicator	Number of Students (Score > 0)	% of Students (Score > 0)	Number of Students (Score = 4)	% of Students (Score = 4)
1a	F	30	93.80	30	93.80
	E	30	93.80	30	93.80
	I	31	96.90	30	93.80
1b	F	12	37.50	0	0.00
	E	1	3.10	0	0.00
	I	7	21.90	6	18.80
1c	F	26	81.30	24	75.00
	E	25	78.10	8	25.00
	I	14	43.80	9	28.10
2a	F	16	50.00	6	18.80
	E	12	37.50	0	0.00
	I	3	9.40	0	0.00
2b	F	11	34.40	5	15.60
	E	8	25.00	0	0.00
	I	1	3.10	0	0.00
2c	F	0	0.00	0	0.00
	E	0	0.00	0	0.00
	I	0	0.00	0	0.00

According to Table 5, in Question 1a, nearly all students met indicators F and E, with 30 students (93.75%) meeting each indicator, and 31 students (96.88%) meeting indicator I. In contrast, in Question 1b, only 12 students (37.50%) met indicator F, only 1 student (3.12%) met indicator E, and 7 students (21.88%) met indicator I. The most critical situation occurred in Question 2c, where not a single student met any of the three indicators (0 students, 0.00%).

In terms of full scores (score = 4), in Question 1a, 30 students (93.75%) achieved full scores on all three indicators. However, no students achieved a full score on indicators

F or E in Question 1b, nor did any students achieve a full score on indicators E or I in Question 2a. These findings indicate that junior high school students' Employ and Interpret skills are very limited on questions of moderate to high complexity, consistent with the findings of Wijaya et al. (2014) and Setianingsih et al. (2022).

The following section presents an analysis of the responses from Respondents A1 (moderate category), A22 (low category), and A3 (very low category) to describe their numeracy skills. After the test, interviews were conducted to confirm the written answers.

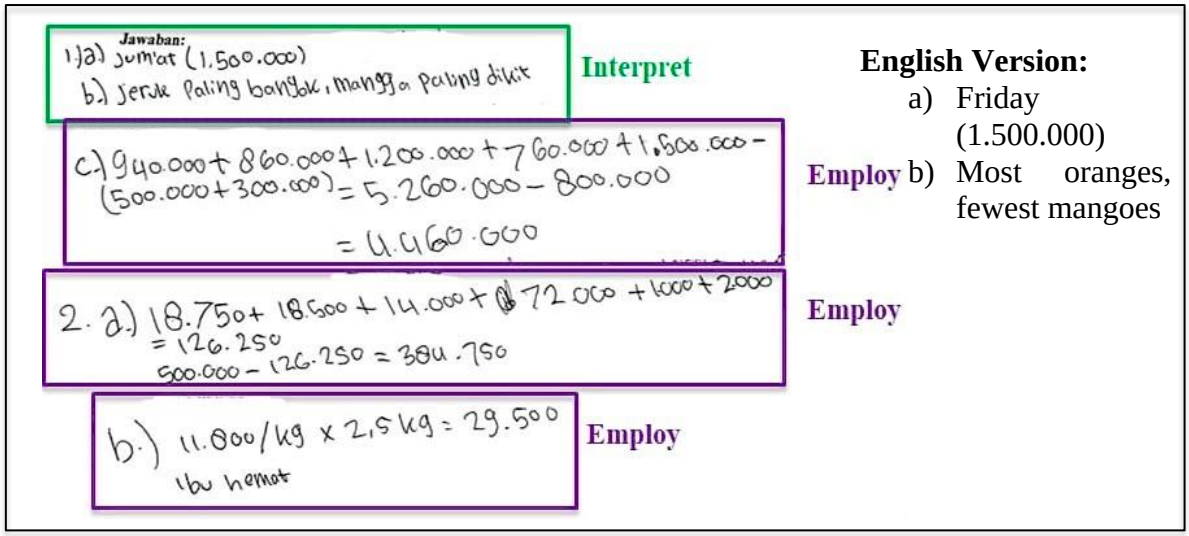
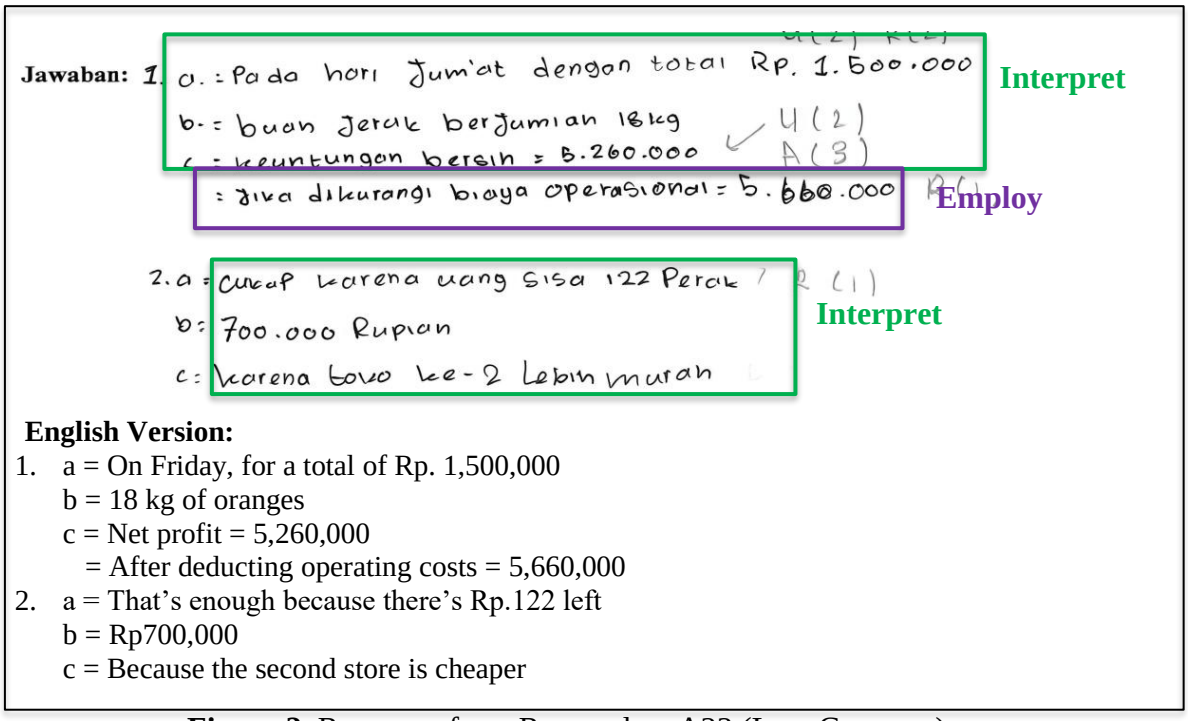


Figure 1. Respondent A1's Answer: Moderate

Based on the test results and interviews shown in Figure 1, an analysis of Respondent A1's numeracy skills was conducted in accordance with the respondent's answers. Respondent A1 demonstrated relatively good Formulate skills in explicit contexts and was able to identify relevant variables and translate them into mathematical operations (Questions 1a and 1c). Specific difficulties emerged in the Formulate stage for implicit contexts. In Question 1b, a semantic encoding error occurred when the respondent interpreted "consistency" as "the most" rather than "the smallest variance," leading to failure across the entire problem-solving chain. In item 1c, Respondent A1 was able to understand the question requiring the calculation of net income after deducting operating costs. The respondent solved the problem by summing total sales from Monday through Friday and then subtracting rent and employee wages. The problem-solving process demonstrated a good understanding of the required mathematical procedures. Respondent A1's Formulate ability in item 1c was evident in the correct identification of net income components, while the difficulty in Employ (multi-step calculation) and the absence of Interpret indicate procedural fluency that had not yet been fully integrated.

In item 2a, Respondent A1 understood the required solution procedure but made an error during the calculation stage, resulting in an incorrect final answer. This indicates that Respondent A1's Employ ability in item 2a had not yet fully developed. In items 2b and 2c, Respondent A1 was unable to understand the questions presented. This was confirmed through an interview, in which the respondent admitted that the written answers were

guesses rather than the result of a systematic mathematical thinking process. This finding indicates that Respondent A1's Interpret ability on high-complexity items remained very limited. This aligns with the findings of Wijaya et al. (2014), who stated that Indonesian students generally encounter difficulties in transforming context into mathematical models, rather than in understanding basic concepts. Limitations in higher-order reasoning are also confirmed by Nusantara et al. (2021), who explained that junior high school students tend to stop at procedures without developing a deep understanding of the problem context.



English Version:

1. a = On Friday, for a total of Rp. 1,500,000
   b = 18 kg of oranges
   c = Net profit = 5,260,000
   = After deducting operating costs = 5,660,000
2. a = That's enough because there's Rp.122 left
   b = Rp700,000
   c = Because the second store is cheaper

Figure 2. Response from Respondent A22 (Low Category)

An excerpt from the interview with Respondent A22 regarding item 2b illustrates this finding:

Interviewer : How did you get the answer to this question?
Respondent A22 : Honestly, I just wrote down a number here. I did not really understand what was being asked, so I guessed.

Based on the test results and interviews shown in Figure 2, an analysis of Respondent A22's numeracy skills was conducted in accordance with the respondent's answers. In item 1a, Respondent A22 was able to understand the question regarding the highest income by reading the entire table, identifying the day with the highest income, and concluding that the highest income occurred on Friday. This indicates that Respondent A22 adequately met the numeracy indicators for that item. In item 1b, Respondent A22 was unable to accurately grasp the concept of "the fruit that sells most consistently." The respondent interpreted the question as asking about the fruit that sold the most, so the answer provided did not align with the question's intent. This error indicates a misconception at the comprehension stage that affected the entire problem-solving process.

In item 1c, Respondent A22 did not write out the complete solution process. However, based on the interview results, Respondent A22 was able to explain the procedure for calculating net revenue quite well and systematically. The respondent could outline the steps to be taken, namely summing the total sales and then subtracting the operating costs. However, an error occurred in the final calculation stage, so the result obtained was not entirely accurate. This indicates that Respondent A22's Formulate and Employ abilities in item 1c had begun to develop, although precision in executing calculations still needs improvement.

For items 2a, 2b, and 2c, Respondent A22 was unable to understand the questions provided. This was confirmed through an interview, in which the respondent admitted that the written answers were merely guesses rather than the result of a systematic mathematical thinking process. These findings indicate that Respondent A22's Employ and Interpret skills on questions of moderate to high complexity remained very limited, meaning that the respondent was not yet able to apply mathematical concepts independently in more complex problem contexts. This pattern is consistent with Setianingsih and Ekayanti (2022), who found that junior high school students generally demonstrate basic competency levels and experience significant difficulties in mathematical reasoning. The gap between verbal ability (the ability to explain) and written performance (the inability to write down a solution) observed in Respondent A22 relates to procedural fluency versus conceptual formulation. According to Umbara and Suryado (2019), true numeracy requires the ability to integrate conceptual understanding with procedural skills in real-world contexts, a competency that still needs to be developed among these respondents.

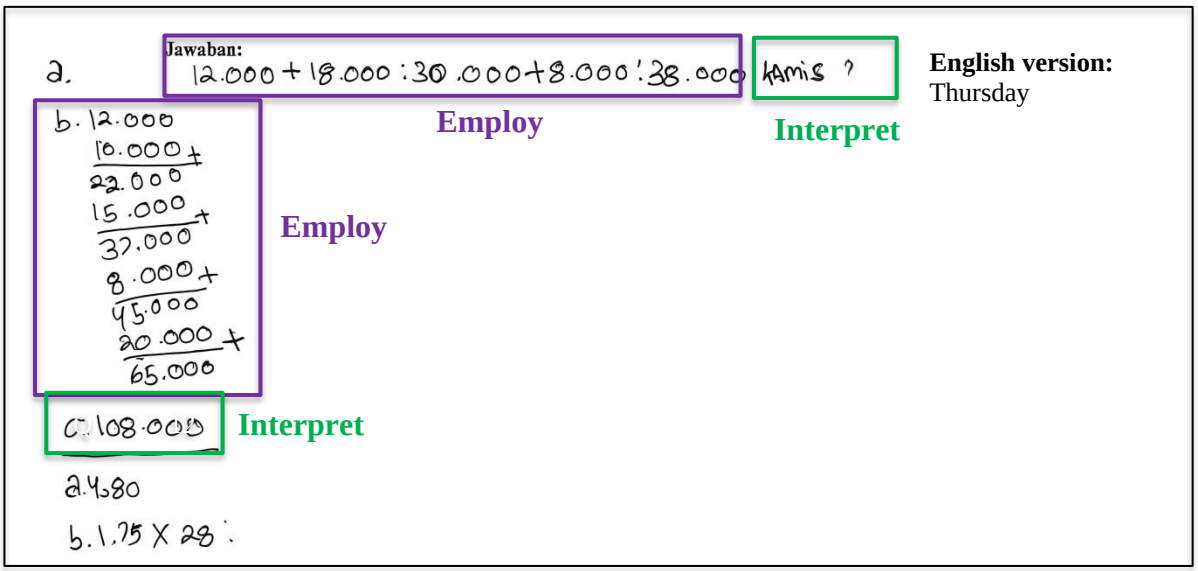


Figure 3. Respondent A3's Answer: Very Low Category

Bas alysis of Respondent A3's numeracy skills was conducted in accordance with the respondent's answers. In item 1a, Respondent A3 was unable to accurately understand the question regarding the highest income. Based on the interview results, the respondent systematically misread and misinterpreted the data in the table, instead picking numbers at random without considering the meaning of the values and symbols presented. This indicates that Respondent A3's Formulate ability in item 1a had not yet developed, as evidenced by the respondent's inability to read and interpret data presented in tabular form. In item 1b,

Respondent A3 was also unable to understand the concept of "the fruit that sells most consistently." Consistent with the pattern in item 1a, the respondent tended to determine the answer without going through a proper data analysis process, so the numbers written down lacked a mathematically justifiable basis. In item 1c, Respondent A3 was unable to correctly solve the net income calculation problem. The respondent did not demonstrate an understanding of the required procedures and again wrote down numbers unrelated to the calculation process that should have been followed.

In items 2a, 2b, and 2c, Respondent A3 was unable to provide correct answers to all items. Based on the interview results, the respondent admitted that they did not understand the questions and could not identify the necessary steps for solving them. A fundamental weakness in accurately reading and interpreting data was the primary obstacle that prevented Respondent A3 from adequately completing all items. This condition reflects a deficit at the most basic stage of numeracy skills, namely understanding data representation (Formulate), which is an essential prerequisite before proceeding to the Employ and Interpret stages. Rakhmawati and Mustadi (2022) also found that weaknesses in accurately reading and interpreting numerical data are among the most common barriers among elementary and junior high school students in Indonesia. This finding underscores the need for learning interventions focused on data literacy and mathematical representation from an early age, as recommended by Miftah and Setyaningsih (2022) through the development of AKM-based worksheets.

CONCLUSION

Based on the results of the data analysis and discussion, it can be concluded that the junior high school students' numeracy skills in this study remained low, with an average score of 30.34%. The majority of students (56.25%) fell into the Low category, followed by the Moderate (25.00%) and Very Low (18.75%) categories. It should be noted that this proportion reflects the 32 students in the purposively selected sample and is not intended to represent junior high school students in general. Analysis by indicator shows a consistent decline from Formulate (38.92%) to Employ (32.08%) and Interpret (29.00%), confirming that higher cognitive demands led to lower performance. In addition, there was a significant gap between Question 1a, which was mastered by 93.75% of students, and Question 2c, which obtained 0%, illustrating disparities in students' mastery of numeracy content.

These findings are reinforced by the qualitative analysis of three respondents. Respondent A1 (moderate category) mastered simple formulation but struggled at the Employ and Interpret stages. Respondent A22 (low category) was able to explain verbal procedures but made calculation errors. Respondent A3 (very low category) struggled from the initial stage of reading the data. This variation highlights the need for a differentiated learning approach. Therefore, junior high school mathematics instruction needs to gradually integrate contextual numeracy-based problems that require higher-order thinking. Teachers should design learning experiences that train students to transform data into mathematical models using a differentiated approach. The implementation of Project-Based Learning and Problem-Based Learning can improve students' Employ and Interpret skills. Further experimental research is recommended to test the effectiveness of these learning interventions.

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