MaPan : Jurnal Matematika dan Pembelajaran
p-ISSN: 2354-6883 ; e-ISSN: 2581-172X
Volume 13, No 1, June 2025 (219-235)
DOI: https://doi.org/10.24252/mapan.2025v13n1a12

An Analysis of Elementary School Students' Number Sense in Solving Numerical Problems

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Received June 19, 2025; Revised June 24, 2025; Accepted June 26, 2025
Available Online June 30, 2025

Abstract:
This study aims to analyze students' number sense abilities in solving number problems at the elementary school level. The method used was quantitative descriptive with 22 fifth-grade students as subjects at SD Muhammadiyah 24 Surabaya. The instrument used was a diagnostic test based on number sense indicators, including estimation, calculation flexibility, and relationships between numbers. The analysis results show that most students (54.5%) are in the medium ability category, 27.3% in the low category, and only 18.2% in the high category. The average score per aspect shows that students are weakest in estimation (52%), while relationships between numbers are the most mastered aspect (68%). These findings indicate that students' number sense abilities are still limited to procedural understanding and have not developed conceptually. Therefore, mathematics learning needs to be redesigned to emphasize the development of numerical intuition and contextual understanding of the meaning of numbers. This study recommends integrating exploration-based learning strategies, alternative strategy discussions, and logical estimation in the teaching and learning process in the classroom.

Abstrak:
Penelitian ini bertujuan untuk menganalisis kemampuan *number sense* siswa dalam menyelesaikan soal bilangan di tingkat sekolah dasar. Metode yang digunakan adalah kuantitatif deskriptif dengan subjek sebanyak 22 siswa kelas V di SD Muhammadiyah 24 Surabaya. Instrumen yang digunakan berupa tes diagnostik berbasis indikator *number sense* yang mencakup aspek estimasi, fleksibilitas berhitung, dan hubungan antarbilangan. Hasil analisis menunjukkan bahwa mayoritas siswa (54,5%) berada pada kategori kemampuan sedang, 27,3% dalam kategori rendah, dan hanya 18,2% dalam kategori tinggi. Rata-rata skor per aspek menunjukkan bahwa siswa paling lemah dalam estimasi (52%), sementara hubungan antarbilangan menjadi aspek paling dikuasai (68%). Temuan ini menunjukkan bahwa kemampuan number sense siswa masih terbatas pada pemahaman prosedural dan belum berkembang secara konseptual. Oleh karena itu, pembelajaran matematika perlu didesain ulang agar lebih menekankan pada pengembangan intuisi numerik dan pemahaman makna bilangan secara kontekstual. Penelitian ini merekomendasikan integrasi strategi pembelajaran

berbasis eksplorasi, diskusi strategi alternatif, dan estimasi logis dalam proses belajar-mengajar di kelas.

Keywords:
Number Sense, Numbers, Elementary School

How to Cite: Vivin, M., Mariana, N., Solihin, A., & Farman. (2025). An Analysis of Elementary School Students' Number Sense in Solving Numerical Problems. *MaPan : Jurnal Matematika dan Pembelajaran*, *13*(1), 219-235. https://doi.org/10.24252/mapan.2025v13n1a12.

INTRODUCTION

The mathematical ability of elementary school students is an important foundation in mastering advanced concepts at the next level of education. One of the key components in learning mathematics is the understanding of number concepts, which includes not only numeracy skills but also the ability to reason flexibly with numbers. This concept is known as number sense, which is the intuitive ability to understand, estimate, and manipulate numbers meaningfully (Reyna & Brainerd, 2023). In the context of basic education, number sense enables students to not only memorize algorithms but also understand why a mathematical procedure can be applied. Unfortunately, various studies show that many students have difficulty understanding number concepts conceptually, so they rely more on mechanical procedures in solving problems (Nunes & Moreno, 2022). Reliance on algorithms alone can hinder the development of students' mathematical thinking in depth. Therefore, number learning that emphasizes the development of number sense becomes very relevant in the context of an independent curriculum that emphasizes holistic competence. This is an important foundation for this research to examine in depth the extent of the number sense ability of elementary school students in solving mathematics problems in number material.

Number sense includes several essential aspects such as understanding place values, flexibility in using counting strategies, the ability to estimate the results of operations, and reasoning on the relationships between numbers (Schulz, 2024). These aspects greatly determine students' success in understanding number operations, especially in the context of solving non-routine problems that require creativity and deep understanding. Many students are able to answer simple calculation questions precisely, but fail when

faced with contextual problems that require numerical reasoning (Xiong, Ding, Liu, Qin, Xu, Yang, Liu, & Cao, 2024). This shows a weakness in number sense, even though his counting skills are good. Previous research has found that students with strong number sense tend to be more adaptive in solving different types of math problems (Hickendorff, 2022). Meanwhile, students who rely solely on algorithms tend to have difficulty when asked to explain the strategies used. This emphasizes that the conceptual mastery of number concepts needs to be developed early in the learning process. Therefore, measuring the ability of number sense is important to provide an initial overview of the condition of students' numerical abilities.

At the elementary level, mathematics education still tends to emphasize procedural learning rather than conceptual understanding (Solihin & Rahmawati, 2024). Teachers often prioritize repetitive algorithmic exercises over fostering deep comprehension of numbers, a practice reinforced by curriculum demands to meet content targets quickly, often at the expense of students' reasoning processes (Putro, Wajdi, Siyono, Perdana, Saptono, Fallo, Khoirotunnisa, Ningsyas, Leuwol, Pationa, Kumalasanti, & Setiyatna, 2023). However, the development of number sense students' intuitive understanding of numbers, estimation, and numerical relationships requires instructional strategies that promote exploration, discussion, and reasoning in varied contexts (Alam & Mohanty, 2023). In practice, many students appear to perform adequately on conventional math assessments but lack the ability to solve problems flexibly and independently. For example, a large-scale study involving over 2,300 elementary students using the AMC Anywhere formative tool found widespread difficulty with tasks involving estimation, number relationships, and reasoning without procedural prompts (Polly, Wang, Martin, Lambert, Pugalee, & Middleton, 2017). Similar patterns are observed in classroom-based assessments, where most students are unable to solve problems without step-by-step guidance from teachers. This reflects a critical gap between procedural proficiency and conceptual number sense. Although previous research Guner and Erbay (2021) has shown that strong number sense correlates with better performance on non-routine tasks, there remains limited research focused specifically on how students' number sense manifests in problem-solving at the elementary level, particularly in the Indonesian context. This study addresses that gap by systematically evaluating students' number sense through diagnostic tasks, aiming to inform more targeted instructional approaches that build flexible and meaningful numerical understanding.

In practice, the development of number sense cannot be done instantly, but through a continuous and integrated learning process. Learning strategies such as group discussions, exploration of numbers through games, and contextual problem solving can be an effective approach in building number sense. Research by Rahayuningsih, Sirajuddin, and Nasrun (2021) suggests that teachers need to provide cognitive challenges that encourage students to think flexibly about numbers. This includes activities that require students to estimate, compare strategies, and reflect on their thought processes. The implementation of this approach requires a paradigm shift from traditional teaching to understanding-based learning (Solihin & Habibie, 2024). In this case, the teacher plays the role of a facilitator who guides students to discover concepts through hands-on learning experiences. Therefore, teachers' understanding of the concept of number sense is crucial in determining the success of its development in the classroom. Learning that encourages the development of number sense also supports the achievement of the Pancasila Student Profile in the aspects of critical thinking and reasoning.

Based on the above description, this research focuses on analyzing elementary students' number sense ability in solving mathematical problems related to number concepts. The study aims to identify the distribution of students' number sense proficiency, examine the characteristics of errors commonly made, and propose recommendations for enhancing instructional practices that emphasize conceptual understanding of numbers. The findings of this study are expected to contribute to the improvement of instructional design in number-related learning, particularly by strengthening conceptual dimensions rather than procedural routines. In addition, the results may serve as a valuable reference for teachers and education policymakers in developing assessment frameworks that prioritize conceptual understanding over mere correctness of answers. Thus, this study holds both theoretical and practical relevance, particularly in supporting national efforts to improve numeracy literacy at the elementary level.

METHODS

This study uses a descriptive quantitative approach to describe students' number sense abilities in solving mathematical problems on number material. This approach was chosen because it is appropriate to systematically and objectively describe the conditions in the field without giving specific treatment to the subjects. The subjects of this study were 22 fifth-grade students at SD

Muhammadiyah 24 Surabaya who were selected purposively based on the representation of diverse academic characteristics. The researcher acted as an active observer and data collector by collaborating with the class teacher to ensure conducive data collection conditions. An observation guideline was used during the process to document classroom interactions, students' problem-solving behavior, and the implementation of the diagnostic test. This instrument included structured field notes and observation sheets designed to capture both quantitative indicators (e.g., frequency of strategy use) and qualitative aspects (e.g., reasoning patterns or estimation behavior). The validity of the instrument content was consulted with three mathematics education experts, and a limited trial was conducted before using it on the primary research subjects. In addition, the reliability test was carried out using the Alpha Cronbach formula with a coefficient result of 0.82, indicating a high-reliability level. This study was carried out ethically by obtaining official permission from the school and approval from the students' parents.

The instrument used was a diagnostic test of number sense ability developed based on indicators from McIntosh, Reys, and Reys (2005). This test consists of 10 open-ended essay questions designed to measure three main aspects of number sense: estimation, flexibility in counting, and understanding of relationships between numbers. Each aspect is developed into several indicators tailored to the context of number learning in elementary schools. Table 1 presents details of the aspects and indicators measured in the instrument.

Table 1. Aspects and Indicators of Number Sense Ability

No.	Number Sense Aspect	Indicators Measured
1.	Estimation	The ability to estimate the results of number operations reasonably
2.	Calculation	The ability to use different strategies in completing number operations
3.	Relationships between numbers	The ability to understand the relationship between numbers, including the use of patterns or relations

The data obtained were analyzed using descriptive quantitative techniques, supported by qualitative analysis of students' error patterns, and triangulated with observational data. Each student's answer on the diagnostic

test was assessed using a rubric with a score range of 0–4 for each item, referring to the completeness and accuracy of reasoning in relation to number sense indicators. The total scores were converted into percentage form and classified into three ability levels as outlined in table 2.

Table 2. Categorization of Number Sense Ability Levels

Score Range (%)	Category	Interpretation
≥ 76%	High	Demonstrates strong conceptual understanding and numerical reasoning.
56% – 75%	Medium	Shows moderate ability with partial conceptual grasp and occasional reliance on procedures.
≤ 55%	Low	Heavily relies on algorithms with limited conceptual reasoning.

In addition to the quantitative scoring, qualitative analysis was conducted to identify common error patterns for each number sense aspect. This involved: 1) Examining students' written responses to detect misconceptions, incomplete reasoning, or strategy rigidity. 2) Categorizing errors based on the type of misunderstanding (e.g., incorrect estimation logic, failure to recognize numerical relationships, or procedural dependency). 3) Describing patterns that emerged across students to understand common learning difficulties within each indicator.

To strengthen the validity of the findings, a triangulation approach was applied by comparing the quantitative test results with qualitative data from classroom observations. Observation notes—collected using structured checklists and field notes—documented students' problem-solving behaviors, such as: 1) Strategy selection and reasoning processes during classroom activities. 2) Students' use of estimation or flexible strategies in oral and group discussions. These triangulated data sets were then synthesized to ensure consistency between students' test performance and their actual behavior in classroom learning, thereby providing a more holistic understanding of their number sense ability.

RESULTS

The results of this study show the distribution of the number of sense abilities of fifth-grade students at SD Muhammadiyah 24 Surabaya based on

high, medium, and low categories. The diagnostic test instrument consists of 10 questions based on number sense indicators covering estimation, calculation flexibility, and relationships between numbers. The results showed that the highest average score was obtained regarding relationships between numbers, achieving 68%. The calculation flexibility aspect was in second place, with an average score of 63%. Meanwhile, the estimation aspect showed the lowest achievement, only 52%. This finding indicates that students are more able to understand numerical relationships between numbers than to estimate results logically. The weakness in the estimation aspect shows that students' number intuition has not developed optimally and is still very dependent on explicit calculation strategies. Table 3 is data that can be used to create bar graphs per aspect of ability.

Table 3. Average Score for Each Aspect of Number Sense

No.	Number Sense Aspect	Average Maximum Score (%)
1.	Estimation	52 %
2.	Calculation	63 %
3.	Relationships between numbers	68 %

Based on the ability category, from a total of 22 students who were the subjects of the study, it was found that the majority of students (12 students or 54.5%) were in the medium category. Six students (27.3%) were in the low category, and four students (18.2%) reached the high category. The distribution of number sense ability categories is presented in table 4.

Table 4. Distribution of Students' Number Sense Ability

No.	Category	Percentage Range Score	Number of Students
1.	High	≥ 76%	4
2.	Medium	56%–75%	12
3.	Low	≤ 55%	6
	Total		**22**

Figure 1 clarifies the visualization of this data, showing a pie chart of the distribution of students' abilities based on their categories. More than half of the students showed mastery of number sense abilities at a moderate level, while the proportion of students who were very strong in this area was still relatively small.

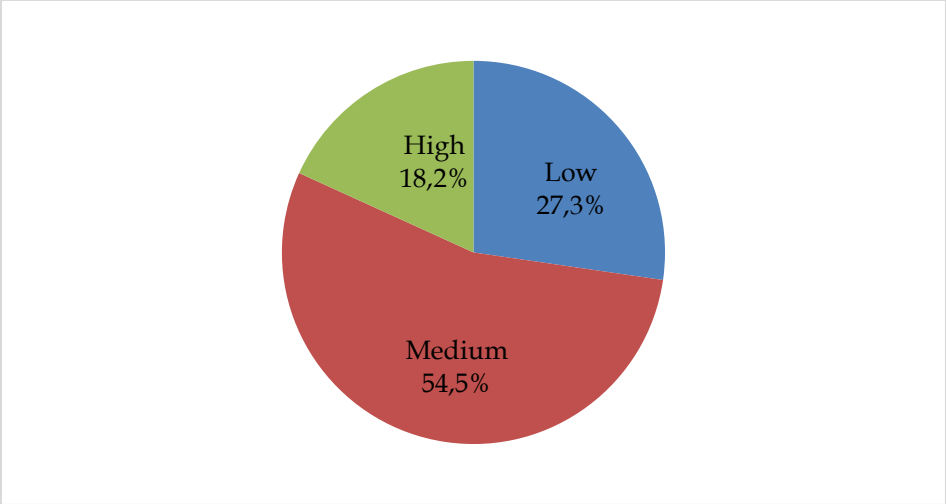

Figure 1. Distribution of Ability Categories

These results confirm that although students have demonstrated an understanding of the meaning of numbers in a relational context, their ability to make quick estimates and choose efficient calculation strategies still requires further attention and reinforcement through a contextual and exploratory learning approach. These data indicate that most students have a developing understanding and have not fully mastered the concept of numbers flexibly and intuitively.

This is evident in various error patterns found across ability categories: High Ability: Students in this category generally showed conceptual understanding and strategy selection. For example, in an estimation task asking, *"Estimate the result of 49 × 21 without calculating it exactly,"* a student answered: *"Because 49 is close to 50 and 21 is close to 20, I estimate 50 × 20 = 1000. So the result should be a bit less than 1000."* This response demonstrates both number sense and flexibility in adjusting quantities meaningfully.

Medium Ability: These students showed partial understanding but often defaulted to standard algorithms. For example, in the same estimation task, a student wrote: *"49 × 21 = 1029. I use the long multiplication method."* Although correct, the student did not attempt estimation and instead relied on exact calculation, indicating a limited grasp of estimation as a reasoning tool.

Low Ability: Students in this group often made procedural or conceptual errors. One student answered: *"49 × 21 = 490 + 210 = 600."* This miscalculation reflects a misunderstanding of place value and multiplication strategies, showing both a procedural and conceptual gap.

Illustration of Error Patterns: In a task requiring students to identify number relationships, such as: *"What is the relationship between 36 and 12?"*, high-ability students responded with: *"36 is a multiple of 12 because 36 ÷ 12 = 3."* While medium-ability students might say: *"36 and 12 are both even numbers,"* which is correct but lacks depth. In contrast, a low-ability student wrote: *"They are different numbers,"* showing no recognition of any numerical relationship.

For flexibility in calculations, a task asked students to solve *"47 + 38"* in any way they preferred. A high-ability student wrote: *"I changed it to 50 + 35 = 85 because 47 is close to 50, and I subtracted 3 from 38."* A medium-ability student used: *"I added 40 + 30 = 70, then 7 + 8 = 15, so 70 + 15 = 85."* While a low-ability student showed confusion: *"I don't know how to do this without using the usual column method."*

These examples highlight how students at different levels approach number tasks differently. Those with higher number sense show flexibility and reasoning, while others rely heavily on rigid procedures or show conceptual misunderstandings.

The results showed that the majority of students were in the category of medium number sense ability, which reflected a numerical understanding that was not optimal. This condition reinforces the previous finding that many elementary school students do not have a strong numerical intuition in dealing with mathematical problems (Merzel, Weissman, Katz, & Galili, 2024). The low proportion of students with high ability categories shows that conceptually mastering the concept of numbers is still a challenge in learning (Rahmawati, Sulistyani, Purnomo, Fitriya, & Ramadhani, 2023). This is in line with the view of Clarke and Beck (2021), who stated that number sense is not just the ability to count, but involves a flexible and meaningful understanding of numbers. In other words, students who rely solely on algorithms without a deep understanding tend to fail in solving problems that require numerical reasoning. This situation shows the need for a learning approach that places more emphasis on the meaning of numbers than just teaching counting procedures. A conceptual understanding-based approach can encourage students to think more critically about the strategies used (Ekawati, Wasis, Shodikin, Fiangga, & Jian-Cheng, 2024). Therefore, the results of this study provide an important indication of the need for revision in mathematics learning strategies at the elementary level. In addition, observation notes by the researcher and the class teacher revealed that during the test session, many students showed hesitation and repeatedly asked whether they were "allowed"

to estimate answers or had to calculate exactly. This illustrates a dependency on procedural guidance and a lack of confidence in applying flexible reasoning strategies.

The aspect of number sense with the lowest average is estimation, with a score of only 52%. This indicates that students have difficulty reasoning about the results of number operations without performing explicit calculations. Estimation ability is an important indicator in numeracy literacy and daily decision-making (Reyna & Brainerd, 2023). This difficulty can be caused by a learning pattern in the classroom that focuses more on definite answers than on the process of estimating thought. Teachers tend to emphasize accuracy in answers, so students feel hesitant to use the estimation approach. According to Andrews, Sunde, Nosrati, Petersson, Rosenqvist, Sayers, and Xenofontos (2021), estimation is an integral part of flexible numerical thinking, allowing students to develop rapid reasoning skills. Learning that does not leave room for exploratory estimation can cause students to be less trained in logical estimation. Therefore, it is necessary to develop a learning strategy that explicitly trains estimation skills through contextual and open activities (Purwoko, Widiyanah, Setiawan, & Nurismawan, 2025). Observation also indicated that during estimation tasks, students frequently attempted to convert the problem into a precise calculation using standard algorithms, rather than approximating. Only a small number were seen using intuitive strategies such as rounding or benchmarking, which suggests limited classroom practice in this area.

Meanwhile, the aspect of calculating flexibility occupies the middle position with an average score of 63%. This shows that some students have begun to be able to use more than one strategy in solving arithmetic problems, but are not fully efficient. Computational flexibility indicates the ability to choose and apply the most appropriate strategy based on the context of the problem (Solihin, Habibie, & Rahmawati, 2024). However, if the strategy used is monotonous and not adjusted to the nature of the problem, then this shows that the flexibility is immature (Nababan, Saprayani, Mutia, Syahira, Menda, Ginting, Ramadani, & Ananda, 2025). Many students are still stuck using a single standard procedure, such as conventional deduction algorithms, although there are other, simpler ways. According to Rasyid, Aini, and Varghesse (2023), flexible thinking skills can be developed through the practice of varied questions and encouraging discussion of alternative strategies. Learning that encourages students to explain the reasons for choosing strategies

is also essential to reinforce this flexibility. Therefore, teachers need to provide a reflective space for students to compare different completion strategies in number learning. Based on observation, it was found that only a few students tried using alternative strategies such as breaking numbers into parts or making approximations, and these students typically did not complete their responses confidently. Most students began their work by immediately setting up vertical algorithmic operations, suggesting limited internalization of flexible thinking as a norm.

The aspect with the highest score in this study was the relationship between numbers, which was 68%. This shows that students are relatively better able to recognize patterns and relationships between numbers, such as multiples, factors, and comparisons. Understanding the relationships between numbers is an important foundation for mastering further mathematical concepts such as fractions, ratios, and proportions (Moyo & Machaba, 2021). This ability also reflects the early development of algebraic thinking that is needed for higher mathematics education. According to Mariana and Sasmita (2024), early recognition of number patterns can facilitate a better transition to formal concepts. Success in this aspect may be due to the students' experience in dealing with number patterns in routine practice questions. However, it should be underlined that the recognition of relationships between numbers should not stop at pattern identification, but also includes the ability to explain those relationships conceptually. Thus, learning strategies that prioritize numerical relationships and the meaning of number structures need to be strengthened. During the observation, students generally showed more confidence when working with number pattern problems. Some were seen using trial-and-error strategies, while a few attempted to explain their answers using verbal reasoning when prompted, indicating greater familiarity and comfort with this type of task.

The distribution of number sense abilities that are more in the medium category shows the potential that can be developed through appropriate learning interventions. Students in this category generally have an adequate numerical foundation but are still weak in terms of flexibility and strategic understanding. In this context, teachers play an important role in facilitating the development of students from medium to high ability (Hidayatullah & Ekawati, 2021). Problem-solving-based learning and the use of concrete media can be an effective approach in developing aspects of number sense (Torres-Pena, Pena-Gonzalez, & Ariza-Echeverri, 2025). In addition, mathematical dialogue

between students and teachers is also essential for building deeper numerical awareness. Activities such as estimating, comparing results, and reflecting on thought processes should be part of daily learning. This can reduce students' reliance on algorithmic procedures and encourage the exploration of more meaningful mathematical ideas. Therefore, the results of this study emphasize the importance of changing the approach to mathematics learning from instructional to constructivist.

The pattern of student errors in answering questions shows that many students have difficulty interpreting questions that are open-ended or contextual. This indicates the weakness of representation and understanding of the meaning of numbers in a real context. Students tend to memorize formulas and procedures without understanding why and when those strategies are used. Nilimaa (2023) emphasized that students with developed number sense tend to be able to evaluate the fairness of answers and adjust strategies when needed. In contrast, students with low number sense are more likely to make procedural errors even on simple problems. These findings reinforce that conceptual understanding is an important element in number learning. Therefore, learning needs to be designed to foster reflective thinking skills, not just to pursue the accuracy of the final result. Evaluation of students' thinking processes should be an integral part of mathematics learning assessment.

Based on the results of the research, it can be concluded that a mechanistic learning approach is not enough to build a strong sense of numbers. Teachers need to design activities that encourage students to manipulate, explore, and interpret numbers in a variety of situations. This can be done through a project-based approach, a numerical game, or estimation activities that are relevant to everyday life. According to Lacka, Wong, and Haddoud (2021), a learning environment rich in number exploration will help students build a deeper understanding. In addition, the use of technology such as interactive mathematics applications can also be an alternative in strengthening students' numerical intuition. These strategies need to be integrated into the curriculum systematically, not just as an additional activity. Thus, the development of number sense can go hand in hand with the achievement of national curriculum goals. Changes in the teaching paradigm are a key factor in the transformation of numeracy literacy of elementary school students.

In terms of the role of teachers, the findings of this study confirm the need to improve pedagogic competence and content related to number sense. Many teachers still understand mathematics as a collection of procedures and

formulas, not as a means of thinking and reasoning. Teachers who understand the meaning of numbers in depth will be better able to guide students in exploring numerical concepts contextually (Friesen & Kuntze, 2021). Therefore, teacher training must include strengthening conceptual understanding and number sense learning strategies. One of the efforts that can be made is through lesson studies and collaboration between teachers in designing understanding-based learning (Ekawati, Wasis, Shodikin, Fiangga, & Jian-Cheng, 2022). With the active involvement of teachers in reflection and the development of learning strategies, it is hoped that the mathematics learning process will be more meaningful for students. These changes require support from policymakers and ongoing professional development. That way, strengthening the number sense can be effectively integrated into the basic education system.

Overall, the results of this study provide important implications for curriculum development, learning strategies, and assessments at the basic education level. The number sense ability that has not been optimal indicates that students' numeracy literacy is still at the development stage. For this reason, curriculum improvement needs to focus not only on content but also on learning approaches that encourage numerical exploration. This study also shows the importance of periodic diagnostic evaluation to map the development of students' numeracy (Sukmaningthias, Sari, & Pratiwi, 2024). This kind of evaluation can provide an overview of the effectiveness of learning and the need for necessary interventions. In addition, open-task-based formative assessments can also encourage students to think more flexibly and critically. Thus, the results of this research can be the basis for more effective learning planning and decision-making. The reform of basic mathematics education needs to be oriented towards strengthening in-depth and sustainable numerical thinking skills.

CONCLUSION

Based on the study's results, the number sense ability of fifth-grade students at SD Muhammadiyah 24 Surabaya is still at a development level that needs improvement. Most students (54.5%) are in the moderate category, while only a small portion (18.2%) show high abilities. These findings indicate that students' number sense is still limited to procedures and has not yet achieved flexibility and mature numerical reasoning. The aspects of number sense were analyzed, and the relationship between numbers showed the highest results (68%), followed by calculation flexibility (63%). The estimation aspect was in the

lowest position (52%). The low estimation ability reflects the weakness of students' numerical intuition in estimating logically without relying on algorithms. Such results suggest that mathematics learning in elementary schools needs to strengthen conceptual understanding, train alternative strategies, and contextually explore the meaning of numbers. Therefore, developing students' number sense requires systematic and sustainable pedagogical intervention. This study recommends that teachers design learning that facilitates estimation, flexibility, and number relations through a problem-solving approach and strategy discussion.

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