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Number sense of junior high school students based on learning speed: Slow, average, and fast learners

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Abstract

Students' learning speed and number sense are critical aspects of mathematics education, yet little is known about how these factors interrelate across different learner profiles. Addressing this gap, this research investigates the characteristics of students' number sense in relation to their learning speed, providing a novel perspective on tailoring mathematics instruction. This qualitative case study involved 185 8th and 9th students from seven junior high schools across seven sub-districts in Sukabumi, Indonesia, who had previously studied fractions. The research was conducted in three stages: identifying learning speed through IQ scores, self-assessment, and teacher evaluations; administering a diagnostic test to assess number sense; and analyzing the number sense characteristics of representative students from each learning speed category. Findings reveal a comprehensive mapping of learning speeds, highlighting the role of factors such as conceptual understanding, study habits, and mathematical content processing in number sense achievement. Notably, differences were observed among slow, average, and fast learners, suggesting the need for differentiated instructional strategies. The implications of this study emphasize the importance of targeted approaches in mathematics teaching, enabling educators to foster inclusive environments that cater to diverse learning needs. This research contributes a unique methodology for integrating cognitive and practical assessments to better understand and support students' mathematical development.

Keywords: Average Learners, Fast Learners, Learning Speed, Number Sense, Slow Learners

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The study of students' intellectual abilities has emerged as a central focus in understanding student characteristics, encompassing a wide spectrum from those with learning disabilities (Vos et al., 2016; Black et al., 2017; Balkist & Agustiani, 2020) to individuals exhibiting high intelligence (Karim et al., 2018; Nurhastuti et al., 2018; Patmawati et al., 2022), as well as offering a broader perspective (Emmiyati et al., 2014; Sudihartinih & Wahyudin, 2019). In contemporary educational discourse, intellectual intelligence has garnered increased attention as a means of assessing students' potential. The concept of intellectual intelligence, originating in the late 19th century, can be traced back to the pioneering intelligence tests developed by French psychologists Alfred Binet and Theodore Simon (Binet, 1905). This framework was further refined with the 1916 Stanford-Binet test, which introduced the Intelligence Quotient (IQ) as a measure for evaluating students' cognitive abilities. Intellectual intelligence is broadly defined as an individual's overall capacity to plan, reason, set goals, and effectively adapt to and interact with their environment (Wechsler, 1939). The IQ scale has since been adapted to account for cultural, linguistic, and national variations (Canivez et al., 2021).

Wechsler's revised scale, published in 2008, categorizes intelligence based on IQ scores into the following ranges: Very Superior (IQ ≥ 130), Superior (120 ≤ IQ < 130), High Average (110 ≤ IQ < 120), Average (90 ≤ IQ < 109), Low Average (80 ≤ IQ < 90), Borderline (70 ≤ IQ < 80), and Extremely Low (IQ < 70). Students' cognitive characteristics are often assessed through the analysis of IQ scores, with the majority of students falling within the Borderline to Very Superior IQ categories. IQ scores provide valuable insights for educators regarding the rate at which students learn; however, further observation is required to account for students' overall health and daily behavior. Learning speed is typically classified into categories such as slow learners, average learners, and fast learners.

In the context of Indonesian education, learning speed is primarily evaluated based on teachers' subjective judgments derived from daily classroom activities, particularly in mathematics. While many schools administer IQ tests, these results could serve as a more reliable tool for identifying and mapping students' cognitive abilities. By integrating IQ test data with teachers' observational assessments, a more comprehensive and objective evaluation of students' learning speeds can be achieved. This integrated approach would enable educators to tailor their teaching strategies to better accommodate the diverse needs of students, thereby improving learning outcomes (Santrock, 2019; Slavin, 2021). Despite the potential benefits, the application of IQ tests in this manner remains insufficiently utilized in numerous educational settings.

Mathematics learning presents distinct challenges for slow learners, who typically fall within the Borderline and Low Average IQ categories. Research has shown that slow learners, both globally and within Indonesia, encounter significant difficulties in grasping abstract mathematical concepts, performing arithmetic operations, and employing problem-solving strategies in mathematics (Kaznowski, 2004; Baglio et al., 2016; Sintawati et al., 2022; Khaira & Herman, 2020; Sovia & Herman, 2020). Additionally, they often experience challenges with concentration, exhibit shorter attention spans than their peers, struggle to follow multi-step instructions, and find it difficult to synthesize information (Setyawan et al., 2021). As a result, mathematics is frequently their most difficult subject (Fritz et al., 2019). These struggles are attributed to cognitive limitations that hinder their ability to process and retain complex information, particularly in subjects that demand sequential and logical reasoning, such as mathematics (Morgan, 2013; Handa, 2019).

In contrast, average learners demonstrate learning speeds that align with their peers, grasping the material effectively and progressing through the general curriculum with ease. Students categorized within the average to high average IQ ranges typically fall into this category. Fast learners, on the other hand, possess an IQ above 130, falling into the Very Superior range. They tend to exhibit above-average creativity and task commitment. These learners are often referred to as gifted or talented children (Renzulli, 1978). The development of exceptional talent, as a result of the interaction between genetic predispositions and environmental factors, is influenced by both genetic and developmental elements (Gagné, 2004; Gagné, 2013). Fast learners typically master new material with ease but often experience boredom and frustration due to the lack of intellectual challenges in the classroom. Additionally, they show a preference for engaging in discussions with adults and enjoy critiquing questions rather than merely answering them.

In the late 20th century, a psychological concept known as number sense was introduced to describe an individual's ability to understand numbers and their operations, estimate quantities, and employ flexible strategies for making mathematical decisions (Greeno, 1991; McIntosh & Dole, 2000; Dehaene, 1997; Sood & Jitendra, 2007; Wilson et al., 2009; Yang, 2005). Number sense is regarded as a crucial arithmetic skill in mathematical learning, often considered an essential foundational competency in mathematics (NCTM, 2000). It encompasses not only students' calculation abilities but also their deep understanding of numbers, their interrelationships, and the operations performed on them.

In Indonesia, number sense is recognized as a fundamental skill in mathematics education, essential for students to develop a flexible understanding of numbers, sharpen their estimation skills, and assess the reasonableness of mathematical results. The significance of number sense is explicitly reflected in various national curriculum frameworks, including the 2013 Curriculum (Kurikulum 2013) and the more recent Merdeka Curriculum (Kurikulum Merdeka), both of which emphasize the strengthening of mathematical reasoning and conceptual understanding (Kementerian Pendidikan dan Kebudayaan, 2013; Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi, 2022). Although number sense is implicitly integrated into the competencies outlined in these curricula, there is limited emphasis on explicit instruction or assessment strategies specifically designed to develop or evaluate number sense.

Research has demonstrated that number sense plays a critical role in students' comprehension of mathematics (McIntosh & Dole, 2000; Dehaene, 1997; Wilson et al., 2009; Yang, 2005). It encompasses skills such as understanding number sequences, estimating numerical values, recognizing the properties of numerical operations, and evaluating the reasonableness of results (Maghfirah & Mahmudi, 2019). Numerous studies have explored the development of number sense in students, along with the challenges they face (Sood & Jitendra, 2007; Andini et al., 2017). However, research specifically investigating the development of number sense among Indonesian students remains scarce, and comparisons with international studies could provide valuable insights into the global standing of Indonesian students in this regard. For instance, students in other countries may demonstrate stronger number sense due to differences in curriculum or educational practices, offering potential guidance for improvements in Indonesia's mathematics education.

One area where students commonly face challenges in developing number sense is fractions. Research indicates that understanding fractions continues to be a significant difficulty worldwide, with students often struggling to grasp fundamental concepts such as visualizing fractions as parts of a whole or distinguishing between various types of fraction representations (Torbeyns et al., 2022; Brown & Quinn, 2020; Bailey et al., 2021). In Indonesia, similar difficulties persist, with many students relying on mechanical procedures rather than developing a deep conceptual understanding (Fauzi et al., 2020). A common issue among Indonesian students is the inability to accurately place fractions on a number line or to interpret fractions within visual contexts, which highlights the challenges they face in mastering fraction concepts (Hariyani et al., 2022; Suryadi et al., 2023). Addressing these issues by examining students' number sense in relation to fractions across varying learning speeds may provide opportunities to tailor instructional support more effectively.

Supporting students according to their distinct learning characteristics has become a central priority in Indonesia, with significant efforts directed towards promoting inclusive education (Balkist & Agustiani, 2020) and the implementation of the Merdeka curriculum to address diverse learning needs (Balkist et al., 2022; Sadieda et al., 2022; Muslimin et al., 2022). On the international stage, differentiated instruction based on learning speed is also widely practiced (Handa, 2019; Morgan, 2013). A common approach adopted by educators involves adjusting instruction to match students' learning speeds; however, this is frequently done without a comprehensive framework for systematically mapping and addressing the individual needs of each student. For example, slow learners typically benefit from additional support, including tailored instructional strategies, extended time for mastery, and reinforcement of foundational concepts. Average learners require consistent and balanced instruction to maintain progress, while fast learners—often classified as gifted—require more challenging material to remain engaged and motivated (Renzulli, 1978; Gagné, 2013). In the absence of targeted support for each group, there is a risk that students may not reach their full potential, particularly in mathematics, where foundational skills are crucial for success. Given these considerations, this study aims to provide a comprehensive investigation into students' learning speed in mathematics, with a focus on exploring their number sense in relation to their learning speed.

METHODS

This study adopts a qualitative research design with a case study approach. To enhance the validity and comprehensiveness of the findings, a relatively large sample of 185 participants was selected from seven distinct schools across multiple districts. This sampling strategy is intended to more accurately capture the diversity in learning speeds among students. The inclusion of participants from various schools and districts enables a holistic view of learning variability and reflects a broad spectrum of educational backgrounds and classroom environments. This approach also aims to demonstrate the presence of students with varying learning speeds—slow, average, and fast learners—across the educational institutions.

The sample consists of 91 eighth-grade students and 94 ninth-grade students, all of whom have completed the instructional content related to number theory. The study seeks to explore potential similarities or differences in number sense between these two educational levels. This methodology allows for a more granular analysis, with data from each grade level being initially examined separately to identify grade-specific trends. Subsequently, the data will be analyzed collectively to provide a general understanding of the development of number sense across middle school levels. This comparative analysis will offer insights into potential shifts in number sense development between the eighth and ninth grades. The research stages and instruments employed are outlined in Figure 1.

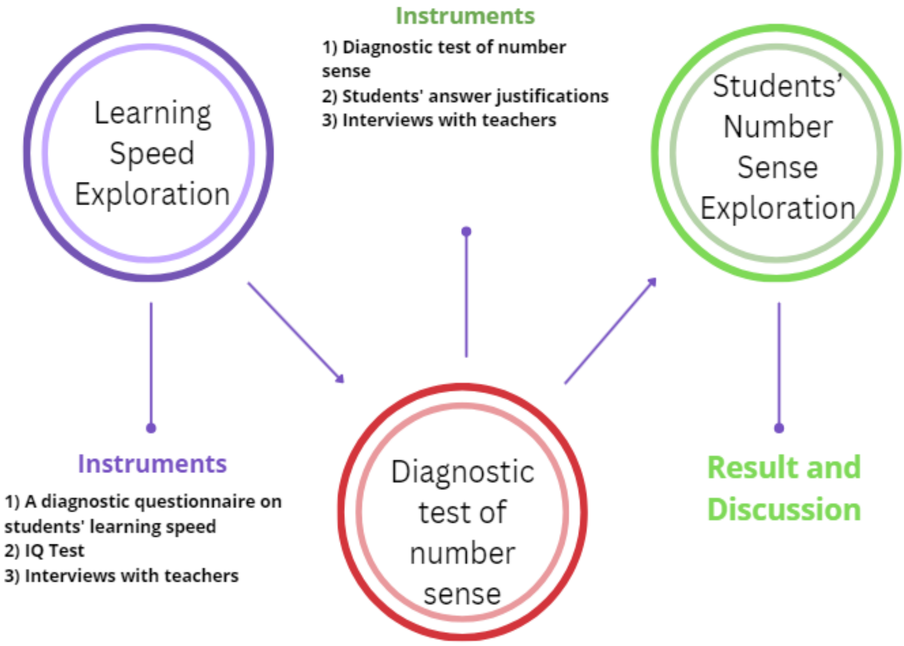


Figure 1. Research Steps

This study employs a qualitative research design with a case study approach. The steps involved in the research process are outlined below.

Exploring Students' Learning Speed from Multiple Perspectives

The first phase of data collection involved the development of a diagnostic questionnaire designed to assess students' learning speeds. This instrument was grounded in relevant theoretical frameworks and previous literature on learning obstacles in mathematics, particularly those related to varying learning speeds. Studies on differentiated learning (Kaznowski, 2004; Baglio et al., 2016) highlight that students who learn at different paces—slow, average, or fast—encounter distinct challenges. Based on these theories, the questionnaire was structured to assess three primary dimensions: students' concentration, their need for repeated exposure to material, and their perceptions of mathematics. These dimensions align with established research on factors influencing mathematics learning outcomes across diverse learning speeds.

Each dimension was explored through three statements, resulting in a total of nine items. To ensure the validity and reliability of the instrument, a panel of experts, including a psychologist, a counseling teacher, and a special education expert, reviewed the questionnaire. The instrument was also piloted with a small group of students to assess its clarity, relevance, and consistency. Feedback from this trial informed final adjustments, after which the refined questionnaire was administered to the study's participants. The diagnostic questionnaire is presented in Table 1.

Table 1. Diagnostic learning speed questionnaire

Dimension	Statement	Response Options
Students' concentration	1. I find it easy to concentrate on math lessons without getting distracted. 2. I stay focused during math problem solving activities until I find a solution. 3. I need extra help to stay focused during math classes.	Never, Sometimes, Often, Always
The frequency of material exposure needs	4. I understand new math topics after the first explanation. 5. I need multiple examples or explanations before understanding a new math concept. 6. I need to learn more mathematics afterclass.	Never, Sometimes, Often, Always
Students' perceptions of mathematics	7. I feel confident when I am doing math problems. 8. I enjoy learning new math topics. 9. I find math difficult and frustrating.	Never, Sometimes, Often, Always

The study also incorporated students' IQ scores, which were obtained through a psychoeducational test conducted at each participating school. The data was gathered with the collaboration of school guidance counselors and external professionals who assisted in publishing the results.

To supplement the diagnostic questionnaire and IQ test data, interviews with mathematics teachers were conducted to gain qualitative insights into students' learning speeds. These interviews focused on the teachers' observations of students' daily mathematics learning activities. The questions aimed to gather detailed information regarding each student's learning speed and their behavior during mathematics lessons. The interview questions are presented in Table 2.

Table 2. The Interviews Questions

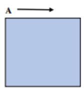
Focus	Question
Students' concentration	How would you describe [student's name]'s level of concentration in mathematics? Do they tend to stay focused, or do they get easily distracted? Compared to their peers, how quickly does [student's name] usually engage with new topics? Are they quick to catch on, or do they take more time?
The frequency of material exposure needs	How often does [student's name] need additional reinforcement (e.g., repeated examples or reviews) to understand new mathematical concepts? Would you say that [student's name] generally requires additional practice or explanations outside of regular classroom instruction?
Students'	How does [student's name] generally respond to math challenges? Do they show

perceptions of mathematics	enthusiasm, frustration, or anxiety? Do you observe any patterns in [student's name]'s attitude towards math assignments or tests? For example, are they typically eager, indifferent, or anxious?
Overall Learning Speed in Mathematics	If you were to categorize [student's name] as a slow, average, or fast learner in math, which would you choose, and why? Can you provide examples where [student's name] either excelled or struggled with particular math concepts? What factors do you believe contributed to these outcomes?

Diagnostic Test on Students' Number Sense

A diagnostic test on students' number sense was designed based on established instruments for assessing number sense, with further refinement by Maghfirah and Mahmudi (2019). The test measures four core indicators: understanding number sequences, estimating numerical values, identifying characteristics of numerical operations, and evaluating the reasonableness of results. Each indicator is assessed through a specific task that requires students to demonstrate their understanding of number sense. The diagnostic test tasks are presented in Table 3.

Table 3. Diagnostic test on students' number sense

Indicators	Task
Understanding Number Sequences	Is there any fractional number between $\frac{1}{3}$ and $\frac{2}{3}$? If so, please write down the fractional number!
Estimating Numerical Values	Assuming you have to walk around a square-shaped field like the one below for one full lap. You start from point A and follow the direction of the arrow. Mark the square below to indicate 2/3 of your total journey! 
Identifying Characteristics of Numerical Operations	Compare the result of the fractional number operation between $\frac{3}{7}:\frac{3}{5}$ and $\frac{3}{7}:\frac{3}{8}$. Which one is greater?
Evaluating the Reasonableness of Results	Without using the strategy of successive multiplication, determine the position of the decimal point in the following operation's result. 9436,8 × 0,4775 = 4506072

The diagnostic test was validated through expert review by mathematics teachers, researchers specializing in number sense, and experts in mathematics education to ensure that the tasks were both relevant and appropriate for assessing number sense in middle school students. The test was piloted with a small group of students to evaluate its clarity, relevance, and consistency. Feedback from this pilot phase informed further adjustments, and the refined diagnostic test was administered to the main study participants.

Exploring the Characteristics of Students' Number Sense

Each student's responses will be analyzed for patterns and variations in their understanding of number sense. Differences between the eighth and ninth grades, as well as among different learning speed categories, will be carefully examined to identify trends. Student responses will be grouped according to similarities and differences in their approach to each task. This grouping will allow the researcher to observe how students demonstrate their understanding of number sense, revealing common strategies and misconceptions within each learning speed category.

The responses of all 185 students will be analyzed, focusing on both their answers and the reasoning provided. Special attention will be given to unique cases where students' reasoning is not mathematically sound, situations where incorrect reasoning led to a correct answer, or instances where correct reasoning failed to produce the correct answer. From each learning speed category, one student will be selected for an in-depth interview to explore their thought process and reasoning behind their responses.

After conducting these student interviews, the researcher will review the students' answers and interview insights with their mathematics teachers. This step will help mitigate subjectivity by incorporating the teachers' perspectives on the students' learning behaviors and challenges. Feedback from the teachers will be used to refine the researcher's interpretations of the students' responses, ensuring a balanced and objective analysis that reflects both classroom observations and the study's findings.

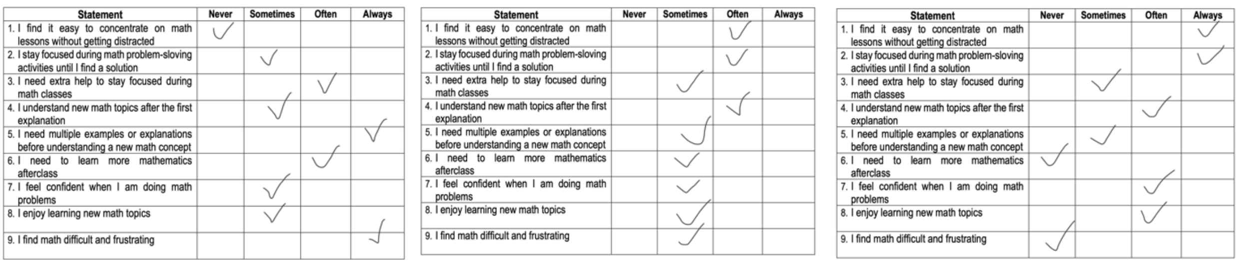
RESULTS AND DISCUSSION

The research aimed to investigate the characteristics of number sense based on students' learning speed. The methodology employed consisted of several key steps: assessing students' learning speed, administering a diagnostic test to evaluate their number sense, and analyzing the characteristics of their number sense. The findings are summarized as follows.

Students' Learning Speed Exploration

To assess students' learning speed, a triangulation approach was employed using three distinct data sets. The first data set was derived from the results of a diagnostic questionnaire designed by the researcher. This questionnaire, which was based on indicators distinguishing slow, average, and fast learners, aimed to evaluate students' perceived learning speed in mathematics. The administration of the questionnaire was the initial data collection process.

The second data set comprised the students' IQ scores, which were obtained from the guidance counselors at each participating school. These scores were assessed using the Wechsler Intelligence Scale for Children (WISC). The IQ testing was conducted at each school, with results gathered in collaboration between the school counselors and external professionals who facilitated the assessment process. The third data set was gathered concurrently with the IQ testing. The form of the questionnaire results is illustrated in Figure 2.



Statement	Never	Sometimes	Often	Always
1. I find it easy to concentrate on math lessons without getting distracted	✓			
2. I stay focused during math problem-sloving activities until I find a solution		✓		
3. I need extra help to stay focused during math classes			✓	
4. I understand new math topics after the first explanation		✓		
5. I need multiple examples or explanations before understanding a new math concept				✓
6. I need to learn more mathematics afterclass			✓	
7. I feel confident when I am doing math problems		✓		
8. I enjoy learning new math topics		✓		
9. I find math difficult and frustrating				✓

Statement	Never	Sometimes	Often	Always
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3. I need extra help to stay focused during math classes		✓		
4. I understand new math topics after the first explanation			✓	
5. I need multiple examples or explanations before understanding a new math concept		✓		
6. I need to learn more mathematics afterclass		✓		
7. I feel confident when I am doing math problems		✓		
8. I enjoy learning new math topics		✓		
9. I find math difficult and frustrating		✓		

Statement	Never	Sometimes	Often	Always
1. I find it easy to concentrate on math lessons without getting distracted				✓
2. I stay focused during math problem-sloving activities until I find a solution				✓
3. I need extra help to stay focused during math classes		✓		
4. I understand new math topics after the first explanation			✓	
5. I need multiple examples or explanations before understanding a new math concept		✓		
6. I need to learn more mathematics afterclass	✓			
7. I feel confident when I am doing math problems			✓	
8. I enjoy learning new math topics			✓	
9. I find math difficult and frustrating	✓			

Figure 2. Form of Questionnaire Results (Left : Slow Learner; Middle : Average Learner; and Right : Fast Learner)

The results of the questionnaire indicate that 40.54% of students self-identify as slow learners, while 45.41% categorize themselves as average learners, and 14.05% perceive themselves as fast learners. Analysis of the test items reveals that these students face challenges in understanding mathematics, requiring additional explanations during lessons, struggling to maintain focus, and encountering difficulties when mathematical processes become overly complex (Kaur et al., 2015; Dougherty & Guillette, 2018; Hayes et al., 2019). Moreover, other studies have found that students often exhibit a negative attitude toward mathematics (Capar & Tarim, 2015; Mercader et al., 2017). Such negative attitudes may stem from an environment that is not conducive to fully engaging students with the material (Cheng et al., 2019; Hwang et al., 2021).

In terms of IQ categorization, the data show that 41.08% of students fall within the Borderline to Low Average range, while 47.57% of students fall within the Average to High Average range. A smaller proportion, 11.35%, is classified within the Superior to Very Superior range. These findings align with previous research, which identifies typical IQ score categories in educational settings, ranging from Borderline, Low Average, Average, High, Superior, to Very Superior (Poh et al., 2019; Roording-Ragetlie et al., 2021). Additional insights into teachers' perspectives on their students' learning speeds are summarized in Table 4.

Table 4. Some excerpts from interviews with teachers regarding their students' learning speeds

Learning Speed	Excerpt
Slow learner	*"I've noticed that [student] often struggles to stay focused in class and gets distracted easily. They need a lot of repetition to grasp basic concepts."*
	"[Student] usually requires several examples and additional review to understand new material. Even then, their assignment results are often not satisfactory."
	"Math seems to make them anxious, especially when faced with slightly more challenging problems. Their math scores are frequently below average."
Average learner	*"[Student] tends to stay focused in class, although they occasionally get distracted. They need a bit of extra time to grasp new concepts, but usually understand after a few additional examples."*
	"Their math assignments are generally complete, but there is room for improvement in quality. Their scores are average—not particularly high, but not low either."
	"Sometimes they show enthusiasm when solving easier problems, but they seem slightly anxious or hesitant as the problems become more challenging."
Fast learner	*"[Student] displays a strong level of focus in class and understands new material quickly, rarely needing repetition."*
	"Their math assignments are always complete and typically accurate. Their math scores are notably high compared to their peers."
	"They seem very enthusiastic about tackling math challenges, and they often enjoy finding more difficult problems to solve."

The results from the teacher interviews indicate that 40% of students are categorized as slow learners. This classification is based on the teachers' observations of students' daily activities, including classroom engagement, assignment completion, and mathematics performance, all of which remain consistently below expectations. In contrast, 49.19% of students are classified as average learners. This judgment is grounded in the observation that while these students generally complete their assignments, there is room for improvement in both their class participation and mathematics scores. The remaining students are identified as fast learners, with teachers noting that these students consistently exhibit high levels of engagement in class, complete assignments thoroughly, and achieve excellent scores in mathematics.

The teacher’s perspective aligns with the general notion that observations of students' daily behaviors—such as classroom activity and assignment completion—play a significant role in influencing their overall learning process (Südkamp et al., 2012; Biesta et al., 2015; Carless & Boud, 2018). The findings from the first and third data sets are summarized in Table 5, under the columns "Questionnaire Result," "Teacher Interview," and "Triangulation." In these tables, SL represents the probability of slow learners, AL indicates the probability of average learners, and FL corresponds to the probability of fast learners. The results from the second data set are presented in Table 2 under the column "IQ Scores Categorize," where B-L denotes the Borderline-Low category, A-H represents the Average-High category, and S-V indicates the Superior-Very Superior category.

Table 5. Comparison result of students’ questionnaire result, IQ score categorize, and teacher interviews at each school for triangulation

School	Questionnaire Result			IQ Score Categorize			Teacher Interview			Triangulation		
	SL	AL	FL	B-L	A-H	S-V	SL	AL	FL	SL	AL	FL
A	14	12	9	12	17	6	14	11	10	14	12	9
B	16	7	3	15	10	1	3	17	6	13	10	3
C	14	15	4	13	16	4	12	16	5	13	16	4
D	10	16	2	11	15	2	7	19	2	10	16	2
E	12	14	3	14	13	2	14	11	4	14	13	2
F	5	10	2	5	9	3	4	9	4	5	9	3
G	4	10	3	6	8	3	4	8	5	5	8	4

Data triangulation was conducted using three distinct data sources: the student questionnaire, IQ scores, and teacher interviews. This approach ensures a comprehensive categorization of students' learning speed. In cases where discrepancies arose between the results from these three sources, a thorough analysis was conducted in consultation with the teachers, examining all three factors and referencing the characteristics associated with each learning speed category. The triangulated data on students' learning speed are presented in Table 5 under the "Triangulation" column.

The results indicate that 80.54% of the data demonstrate consistency across the student questionnaire, IQ scores, and teacher interviews. This finding is consistent with previous research on the correlation between IQ scores and students' learning abilities, as observed in a study spanning 56 countries (Lynn & Mikk, 2009). However, 19.46% of the data revealed discrepancies among the three sources. These discrepancies were further analyzed during the triangulation process, leading to a refined interpretation of the data, which served as a foundation for exploring students' learning speed.

Overall, the distribution of students’ learning speeds across all schools is as follows: 40% are classified as Slow Learners, 45.41% as Average Learners, and 14.59% as Fast Learners. Notably, the proportion of Slow Learners has increased compared to previous studies, where the distribution typically did not approach the proportion of Average Learners (Flynn & Weiss, 2007; Filippetti & Richaud, 2016).

Students’ Number Sense Test

Following the categorization of students based on their learning speed, the next phase of the research involved administering a diagnostic test to assess students' number sense. The responses from each student were analyzed to identify patterns and variations. Special attention was given to differences in responses between students in grades 8 and 9, as well as among those with varying learning speeds, in order to detect emerging trends. The student responses were subsequently grouped based on similarities and differences in their approaches to each question. This grouping process enabled the researcher to examine how individual students, or groups of students, demonstrated their understanding of number sense, thereby highlighting common strategies and misconceptions within each learning speed category.

The answers of 185 students were systematically analyzed, focusing on both their responses and the reasoning behind them. Unique responses were selected for further examination. These included instances where the reasoning was non-mathematical, cases where the reasoning was incorrect but the answer was coincidentally correct, situations where the answer was incorrect despite the reasoning being sound, and instances where the answer was correct but the explanation provided was inadequate. From each learning speed category (slow, average, and fast learners), one student was selected for in-depth interviews. These interviews aimed to explore the students' thought processes and reasoning behind their responses, offering a more nuanced understanding of their number sense and the rationale behind their problem-solving strategies.

Additionally, to further enrich the understanding of students' number sense characteristics, interviews were conducted with teachers to gather their perspectives on students' answers from the diagnostic test. These teacher interviews provided valuable insights into students' everyday mathematical thinking processes.

In-Depth Interview Results from Task 1

Following the analysis of student responses, a selection of students was chosen for in-depth interviews. The various responses for Task 1, categorized by students' learning speed, are presented in Table 6.

As observed from Table 6, the patterns of responses show similar variations in both 8th and 9th grade students. A significant number of students did not complete the task according to their learning speed, which is consistent with the possibility that these students lack prior learning experiences and have not yet developed a positive attitude toward mathematics (Lee et al., 2023; Siregar et al., 2023). Among the students who provided incorrect answers, this may be attributed to incomplete learning experiences, leading to obstacles in understanding the material and limitations in their ability to interpret assignments (Bermejo & Blanco, 2009; Lai et al., 2015; Ardi et al., 2019).

Additionally, some students correctly completed Task 1, but their reasoning and problem-solving steps were not necessarily accurate. These students' thought processes need to be further examined to better understand their approach. Despite Task 1 being relatively simple, it encouraged students to attempt answering, although the accuracy of their solutions still requires attention. This suggests that tasks with clear and straightforward instructions can motivate students to engage with the content (Al-Mashaqbeh, 2016; Novita et al., 2022).

Table 6. Varied responses for Task 1 based on students' learning speed

Task	Various Responses	Slow Learners (people)		Average Learners (people)		Fast Learners (people)	
		8^{th} grade	9^{th} grade	8^{th} grade	9^{th} grade	8^{th} grade	9^{th} grade
Is there any fractional number between $\frac{1}{3}$ and $\frac{2}{3}$? If so, please write down the fractional number!	No answer	12	14	13	15	2	4
	It doesn't exist	14	11	16	14	3	1
	1	2	3	1	2	1	1
	½ (the correct answer)	5	7	9	10	6	7
	The others	3	3	3	1	1	1

Furthermore, A unique answer from a slow learner is illustrated in Figure 3.

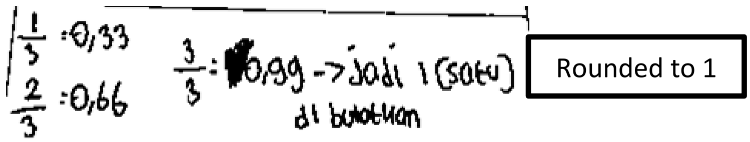


Figure 3. A unique answer from a slow learner for task 1

The following excerpt from the researcher's interview with the student reveals insights into their reasoning:

R : “If 0.99, or what you rounded to 1, where does it fall in relation to 1/3 and 2/3?”
SL : “After 2/3, ma’am.”
R : “Take another look; there’s the word 'between.' What does that mean?”
SL : “Oh yes, it should be in the middle, right? But it seems like there isn’t one, ma’am, because after 1/3 comes 2/3. Since the denominator stays the same, right? So after 1 is 2. Therefore, the answer is that there is no fraction between 1/3 and 2/3.”

The teacher’s response indicates that the student’s understanding, particularly regarding fractions, is incomplete. One key issue is the student’s inability to sequence fractions in order from smallest to largest when the denominators differ. Additionally, the student struggled with interpreting the key phrase "in between" in the task. Initially, the student perceived a number pattern between 1/3 and 2/3, but could not identify the fractional numbers that fit within this range. This difficulty is consistent with learning challenges often encountered by middle school students (Arbaugh et al., 2005; Chapman, 2013; Jupri & Drijvers, 2016; Jupri et al., 2014; Afriyani et al., 2018). Upon further clarification, the student was able to understand the task's intent, but remained confused about the presence of other fractions between 1/3 and 2/3, perceiving them as too similar. This reinforces the challenge of understanding the density properties of fractions (Sugiman & Murdiyani, 2019; Hariyani et al., 2022). Thus, we conclude that the slow learner did not demonstrate the number sense indicator related to the ability to identify the sequential nature and regularity of numbers.

A unique answer from an average learner is shown in Figure 4.

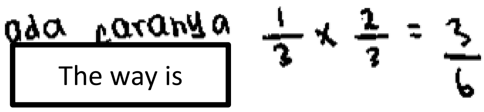


Figure 4. A unique answer from an average learner for task 1

The following excerpt from the researcher’s interview with the student provides further insight:

AL : “The method is simply multiplication, ma'am, so 1/3 x 2/3 = 3/6.”
R : “How did you get the numbers 3 and 6 in the result?”
AL : “By adding, ma'am, 1 + 2 and 3 + 3.”
R : “So, when fractions are multiplied, each numerator and denominator are added, right?”
AL : “Yes, ma’am.”

The teacher’s response reveals that while the student correctly answered Task 1, their reasoning was flawed. The student seems to have misunderstood the concept of fraction multiplication and instead applied addition to the numerators and denominators. This misunderstanding highlights a gap in the student’s comprehension of fraction density and multiplication operations (Trivena et al., 2017; Andini et al., 2017). Consequently, the student has not fully grasped the density properties of fractions or the rationale behind fractional multiplication. We conclude that the average learner also did not fulfill the indicator of the ability to identify the sequential nature and regularities of numbers.

A unique answer from a fast learner is presented in Figure 5.

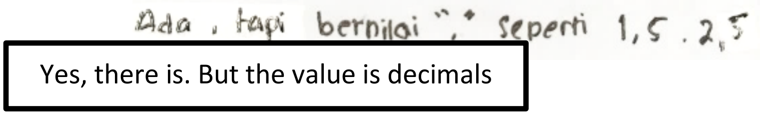


Figure 5. A unique answer from a fast learner for task 1

The following interview excerpt with the fast learner provides further insights:

R : “Do you think that 1.5 is between 1/3 and 2/3?”
FL : “No, it means there will be fractions between 1/3 and 2/3, but in decimal form, not regular fractions. It's 1.5/3.”
R : “How did you get the answer 1.5?”
FL : “Because 1.5 is between 1 and 2. But 1.5/3 is not a regular fraction.”
R : “1.5/3 can’t be in the form of a regular fraction? Try multiplying by 2/2.”
FL : “Oh yes, so it becomes 3/6.”

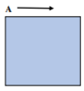
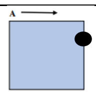
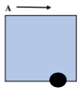
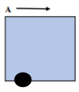
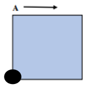
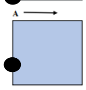
The teacher's response suggests that the student understands the density properties of fractions. However, the student initially failed to recognize other representations of fractions, such as converting decimal fractions to common fractions. After further clarification during the interview, the student demonstrated an improved understanding of fraction density and sequentiality. Although the student's initial response was incorrect, the interview revealed that the fast learner was able to identify the sequential nature and regularity of numbers after further guidance (Andini et al., 2017; Trivena et al., 2017). Thus, the fast learner was able to fulfill the indicator of understanding the sequential nature of numbers and their regularities in the number system.

In-Depth Interview Results from Task 2

Various responses for task 2 based on students’ learning speed presented in Table 7. As shown in Table 7, similar patterns in responses were observed across both 8th and 9th grade students.

Table 7. Various responses for Task 2 based on students’ learning speed

Task	Various Responses	Slow Learners (people)		Average Learners (people)		Fast Learners (people)	
		8th grade	9th grade	8th grade	9th grade	8th grade	9th grade
	No answer	3	3	2	3	2	1

Assuming you have to walk around a square-shaped field like the one below for one full lap. You start from point A and follow the direction of the arrow. Mark the square below to indicate 2/3 of your total journey! 		8	7	14	12	2	4
		9	7	10	12	5	4
	 (the correct answer)	9	12	13	11	2	3
		3	5	2	1	1	2
		4	4	1	3	1	0

A significant number of students correctly answered the task. However, a deeper analysis of the thought processes and strategies employed by the students is required to fully understand their reasoning. One particularly unique response from a slow learner is illustrated in Figure 6.

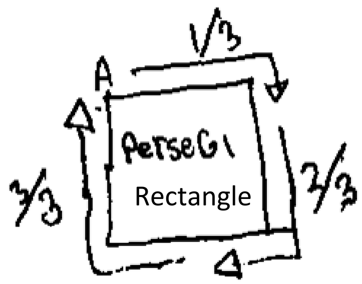


Figure 6. A unique answer from a slow learner for task 2

The following is an excerpt from the interview conducted with the student:

SL : "I divided the perimeter into three parts, and 2/3 is at the end of the second part."
R : "Is that point in the middle?"
SL: "It hasn't reached the middle point yet, ma'am."

The teacher's interpretation of the student's response suggests that the student has a reasonably good contextual understanding of fractions. Although the positioning of the 2/3 point is not entirely accurate, the student's ability to conceptualize fractions within the given context demonstrates a degree of number sense. This aligns with previous research concerning students' precision in fraction tasks (Lortie-Forgues & Siegler, 2017; Ren & Gunderson, 2021; Gea et al., 2023). It can be concluded that the slow learner has fulfilled the number sense indicator, specifically the ability to make approximate estimations and represent the results, even though the exact placement of the 2/3 point is not correct.

A unique response from an average learner is shown in Figure 7.

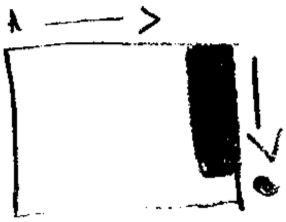


Figure 7. A unique answer from an average learner for task 2

The following is an excerpt from the interview conducted with the student:

R : "How many total steps are there?"
AL : "Three, ma'am."
R : "So, from where to where are the steps? (AL points to the corner below A.) Fractionally, it doesn't complete a full cycle, right? It should return to the starting point, shouldn't it?"
AL : "No, ma'am. If it goes back to the starting point, it would be 1."

The teacher's response indicates that the student has not fully grasped the contextual meaning of fractions. It is evident that the student struggles to visualize the fractional parts in relation to the denominator and cannot correctly conceptualize how the perimeter should be divided into equal sections (Andini et al., 2017; Muchoko et al., 2019). Thus, it can be concluded that this average learner has not yet met the indicator for the ability to estimate numerical results and represent them appropriately.

A unique response from a fast learner is depicted in Figure 8.

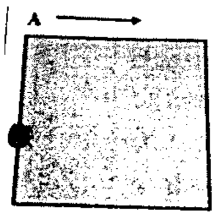


Figure 8. A unique answer from a fast learner for task 2

The following is an excerpt from the interview conducted with the student:

FL : "2/3 is greater than 1/2, right? So, it must pass through the midpoint and approach the endpoint."
R : "Oh, I see. About how much is this point here (pointing to the corner before the decimal point)?
FL : "It seems like 3/4, ma'am. There are 4 corners, and this is the third one."
R : "Okay, so if that's the case, is 2/3 before or after 3/4? (FL nods) In that case, would you like to correct your answer? Where is 2/3 located?"
FL : "Yes, ma'am. It seems to be before the 3/4 point."

The teacher's feedback suggests that the student possesses a contextual understanding of fractions but lacks precision in determining exact locations. While the student is able to visualize the perimeter and associate it with the denominator, they do not demonstrate the accuracy needed to correctly identify the position of the 2/3 point (Widjaja et al., 2008; Muchoko et al., 2019). Therefore, it can be concluded that this fast learner has not fully met the indicator for the ability to make precise estimations and represent numerical results.

In-Depth Interview Results from Task 3

The various responses for Task 3 based on students' learning speed are presented in Table 8. From Table 8, it is evident that similar response patterns emerged among students from both the 8th and 9th grades. Additionally, fewer students across all learning speeds failed to answer the task.

Table 8. Various responses for Task 3 based on students' learning speed

Task	Various Responses	Slow Learners (people)		Average Learners (people)		Fast Learners (people)	
		8th grade	9th grade	8th grade	9th grade	8th grade	9th grade
Compare the result of the fractional number operation between $\frac{3}{7}:\frac{3}{5}$ and $\frac{3}{7}:\frac{3}{8}$. Which one is greater?	No answer	5	6	7	6	1	2
	$\frac{3}{7}:\frac{3}{5}$	18	18	19	18	4	3
	$\frac{3}{7}:\frac{3}{8}$ (the correct answer)	13	14	16	18	8	9

This suggests that the task was sufficiently straightforward to encourage student participation, although accuracy in solving it was still an area of concern. Tasks with relatively simple instructions can stimulate student engagement, as suggested by previous research (Al-Mashaqbeh, 2016; Novita et al., 2022). A balanced distribution between correct and incorrect answers for Task 3 may reflect that students were prompted to make an immediate choice, with the answers readily available within the task itself (Lee & Lee, 2023; Posicelskaya et al., 2023).

A unique response from a slow learner is presented in Figure 9.

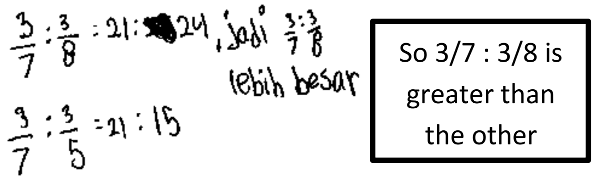


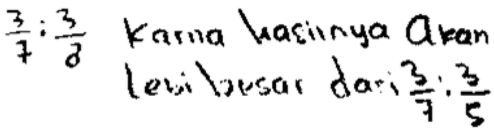
Figure 9. A unique answer from a slow learner for task 3

An excerpt from the interview with the student is as follows:

SL : "It's just cross-multiplication, ma'am. The one at the top, 3x7 divided by 3x8, gives 21:24. Now, the other one, 3x5 divided by 3x7, gives 21:15. The numerators are the same, which is 21. We just need to compare the denominators, which are 24 and 15. Since 24 is larger, the answer is 3/7:3/8. It can be converted to multiplication, but the positions of the fractions are swapped."
R : "Try swapping the positions. How would it look? Please write it down!" (SL writes 3/7 x 8/3)
SL : "3x8 is 24, and 7x3 is 21. It's the same, ma'am, 24 and 21."
R : "That is indeed correct, but ideally, the positions of the numerator and denominator should not be swapped. If we have 24/21 and 15/21, which one is larger?"
SL : "24/21."

Teacher response to the the student's answer is this student recalls the procedure for dividing fractions but has not fully grasped the meaning of the numerator and denominator. Consequently, they are not aware of the roles of the numerator and denominator and are unable to compare fractions perfectly due to not fully understanding their significance. In task 3 even though the student's answer is correct, it is merely coincidental. This is evident from the interview results, which depict a thinking process that is not suitable for finding the correct answer. This student recalls the procedural steps for solving fraction division but has not perfected the understanding of the numerator and denominator's meaning. Cases, where students recall problem-solving procedurally and frequently, make calculation errors due to procedural memory lapses are common. Students often struggle to fully comprehend fraction concepts and face difficulties when encountering contexts different from those provided by the teacher (Andini et al., 2017). From the student's answer, it is apparent that they have not realized the roles of the numerator and denominator, and they cannot perfectly compare fractions' effects. Therefore, it can be concluded that the SL student has not fulfilled the number sense indicator, namely the ability to identify the characteristics of numerical operation results and their implications for various types of numbers.

A unique answer from an average learner is represented in Figure 10.



Because the result will be greater than 3/7 : 3/5

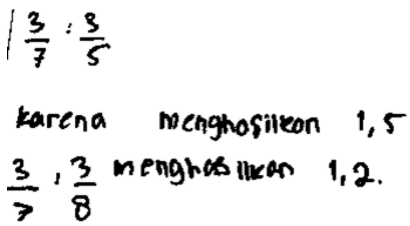
Figure 10. A unique answer from an average learner for task 3

The excerpt from the researcher's interview with the student is as follows.

AL: "Since 8 is larger than 5, 3/8 is smaller than 3/5. So, to make the result larger, we need to divide the smaller one, which is 3/8".

The teacher's feedback reveals that the student is capable of understanding the properties of numbers when divided by larger or smaller values, particularly in the context of fractions. The student can assess the relative size of fractions with the same numerator but different denominators. This indicates that the average learner has fulfilled the indicator for the ability to identify the characteristics of numerical operation results and their implications for various types of numbers.

A unique answer from a fast learner is represented in Figure 11.



Because the result of 3/7 : 3/5 is 1,5. But the result of 3/7 : 3/8 is 1,2

Figure 11. A unique answer from a fast learner for task 3

The excerpt from the researcher's interview with the student is as follows.

R : "Where did you get the values of 1.5 and 1.2?".

FL : "1.5 comes from 7/5 because the 3s cancel each other out. Meanwhile, 1.2 comes from

8/7".

R : "Oh, so you're calculating? If 3/5 and 3/8 are considered, which one is smaller?".

FL : "3/8".

R : "So if you compare the results of 3/7:3/5 and 3/7:3/8, which one is larger?".

FL : "3/5. Because 3/5 is larger; 3/8 is smaller".

The teacher's response suggests that the student has not fully grasped the properties of numbers when divided by larger or smaller values, particularly in the context of fractions. Although the student appears to follow the correct procedure for dividing fractions, they lack a comprehensive understanding of the process. This is evident from their inability to recognize the correct relationship between the fractions involved (Widjaja et al., 2008; Pulungan & Suryadi, 2019). Therefore, it can be concluded that the fast learner has not fully met the indicator for the ability to identify the characteristics of numerical operation results and understand their implications for different types of numbers.

In-Depth Interview Results from Task 4

The various responses for Task 4 based on students' learning speed are presented in Table 9. From Table 9, it is observed that similar response patterns were evident among students in both the 8th and 9th grades. However, only a small proportion of students provided the correct answer to this task.

Table 9. Various responses for Task 4 based on students' learning speed

Task	Various Responses	Slow Learners (people)		Average Learners (people)		Fast Learners (people)	
		8th grade	9th grade	8th grade	9th grade	8th grade	9th grade
Without using the strategy of successive multiplication, determine the position of the decimal point in the following operation's result. 9436,8 × 0,4775 = 4506072	No answer	3	3	8	9	0	0
	45,06072	19	24	20	22	2	2
	450,6072	6	5	7	8	1	1
	4506,072 (the correct answer)	8	6	6	3	10	11
	4,506,072	0	0	1	0	0	0

The majority of students seemed to place the decimal point by counting the decimal places in the first and second numbers, adding them together, and then positioning the decimal in the result accordingly. This indicates that students often rely on imperfect procedural memory when solving decimal fraction problems (Siegler et al., 2014; Dewolf et al., 2015; Hoof et al., 2018).

A unique answer from a slow learner is presented in Figure 12.

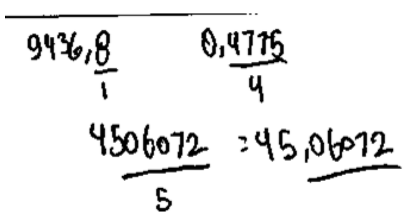


Figure 12. A unique answer from a slow learner for Task 4

An excerpt from the interview with the student is as follows:

SL : "Because the decimal in 9436.8 is 1. Then, the decimal in 0.4775 is 4. Now, the decimals just need to be added, so 1 + 4 = 5. Thus, the result should have 5 decimals. So, 45.06072."
R : "So, if nine thousand something is multiplied by 0.4 something, the result is around 45, right?"
SL : "It seems so, ma'am."

The teacher's response indicates that the student recalls the procedural steps for handling decimal fractions, especially when positioning the decimal point. However, the student does not fully understand that the resulting digits may not always align with what is represented in the problem itself. This lack of understanding is a common challenge for students, as also observed in other research (Widjaja et al., 2008; Pulungan & Suryadi, 2019). It can be concluded that this slow learner has not met the number sense indicator, specifically the ability to assess the reasonableness of a calculation result.

A unique answer from an average learner is presented in Figure 13.

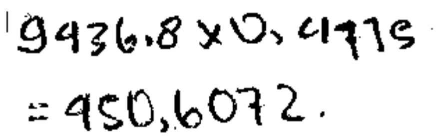


Figure 13. A unique answer from an average learner for task 4

An excerpt from the interview with the student is as follows:

AL : "Because nine thousand is multiplied by a fraction, the result must be smaller than nine thousand."
R : "Four thousand is also smaller than nine thousand, right?" (AL nodded) "So, is the answer still the same, or do you want to adjust the position of the decimal point?"
AL : "Mmm, it's still the same, I think."

The teacher's feedback reveals that the student is aware of the concept that multiplying a number by a fraction between 0 and 1 reduces its value, yet their understanding is incomplete. While the student is able to recall the general principle, their accuracy remains an issue, leading to imprecise calculation results (Widjaja et al., 2008). Therefore, it can be concluded that the average learner has not fully met the indicator for assessing the reasonableness of a calculation result.

A unique answer from a fast learner is represented in Figure 14.

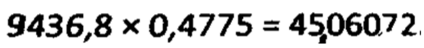


Figure 14. A unique answer from a fast learner for task 4

An excerpt from the interview with the student is as follows:

FL : "Because the total number of decimals is 5, the decimal result should also have 5."

The teacher's response suggests that the student recalls the procedural steps for multiplying decimal fractions, but their understanding is still incomplete. While they are able to follow the correct procedure for handling decimal fractions, they lack a comprehensive grasp of the underlying concepts. Therefore, it can be concluded that the fast learner has not fully fulfilled the indicator for assessing the reasonableness of a calculation result.

Students categorized as Slow Learners tend to rely more heavily on memorized procedural steps when solving mathematical problems, as presented by the teacher, rather than fully comprehending the concepts being taught. This is often attributed to their need for more time to learn and understand symbols, abstractions, and concepts (Sintawati et al., 2022; Khaira & Herman, 2020; Sovia & Herman, 2020). Additionally, these students often struggle with concentration and have shorter attention spans compared to their peers. They find it difficult to follow multi-step instructions and may struggle with drawing conclusions from information (Setyawan et al., 2021). Mathematics is frequently cited as one of the most challenging subjects for them (Fritz et al., 2019).

Finally, it is evident that the stages of mapping students' learning speeds vary considerably, spanning slow, average, and fast learners. This variation was observed in schools located across various regions in Sukabumi. Mapping learning speed can be comprehensively achieved through self-assessment, IQ scores, and teacher interviews regarding their daily mathematics learning activities (Santrock, 2019; Slavin, 2021). The responses from 8th and 9th-grade students show only minor differences, suggesting that the mathematical topics they have studied so far have not significantly impacted their number sense. This finding aligns with previous research indicating that curricula primarily focused on procedural learning may not effectively foster number sense development (Boaler, 2016; NCTM, 2000).

The differences in number sense achievement across slow, average, and fast learners can be attributed to varying levels of conceptual understanding, study habits, and the processing of mathematical content. Slow learners, who often require more time to grasp abstract concepts, tend to focus on approximate estimates rather than a deep understanding of numerical order or the characteristics of mathematical operations (Yang, 2005). Average learners generally possess a solid foundational understanding but may prioritize the end results over critically reflecting on the reasonableness of their calculations, which limits their ability to evaluate outcomes effectively (Gersten & Chard, 2014). Fast learners, with a propensity for rapid comprehension, often focus on concepts such as numerical order and patterns but may skip thorough checks on their results due to confidence in their quick processing skills.

The shared inability of all groups to assess the reasonableness of calculations may reflect a need for more advanced analytical thinking skills. Such skills require not only mastery of the subject matter but also critical and evaluative habits that are still developing at this stage (Gersten & Chard, 2014). These findings have practical implications for mathematics teachers in tailoring instructional strategies based on students' learning speed and number sense capabilities. By recognizing these differences, teachers can design targeted interventions to support slow learners while challenging fast learners, ultimately fostering a more inclusive learning environment. Future research is recommended to explore specific teaching methods and tools that can enhance number sense across diverse student learning speeds, as well as conduct longitudinal studies to examine the impact of these targeted strategies over time.

This research is limited by the use of only three perspectives in determining student learning speed. Future studies could incorporate additional perspectives to develop a more comprehensive framework for understanding learning speed. Moreover, this study provides valuable material for the development of teaching materials, learning media, and instructional models that can improve students' number sense based on their individual characteristics.

CONCLUSION

This study conducted a comprehensive investigation into students' learning speeds through a combination of student questionnaires, IQ scores, and teacher interviews. The analysis revealed notable discrepancies in the learning speeds as reported by these different sources. Despite these variations, the triangulation of data provided a robust basis for inferring students' learning speeds, with significant insights into the factors influencing number sense achievement. The study highlighted that the differences in number sense proficiency across slow, average, and fast learners can be attributed to varying levels of conceptual understanding, individual study habits, and cognitive processing of mathematical content. Furthermore, the shared difficulty among all groups in assessing the reasonableness of calculations suggests a developmental need for more advanced analytical thinking skills, which encompass not only mastery of the subject but also the cultivation of critical and evaluative thinking habits still in progress at this educational stage.

However, there are several limitations to this research that should be acknowledged. Firstly, the study's reliance on a specific set of data sources, such as questionnaires, IQ scores, and teacher interviews, may not have captured the full range of factors influencing learning speeds. Additionally, the study was conducted within a particular educational context, which may not be fully representative of other settings or student populations. The cross-sectional nature of the research also limits the ability to draw causal conclusions or track changes in students' learning speeds over time. Future research could address these limitations by incorporating a wider range of data sources, including observational studies and academic performance records, to gain a more nuanced understanding of the factors influencing learning speeds.

To build upon the findings of this study, further research is recommended to explore specific teaching strategies and tools that can effectively enhance number sense across students with varying learning speeds. Longitudinal studies would be valuable in examining the long-term effects of targeted teaching methods and interventions on students' mathematical achievement. Additionally, expanding the scope of research to include diverse student populations and different educational settings could provide broader insights into the challenges and opportunities for improving number sense in a more inclusive learning environment. Future studies could also investigate the development of specialized teaching materials, learning media, and instructional models that cater to the unique characteristics of slow, average, and fast learners, ultimately fostering more effective and personalized educational practices.

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Declarations

Author Contribution : PSB : Conceptualization, Writing Original Draft, Editing and Visualization.
AJ: Review, Format Analysis and Methodology.

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Conflict of Interest : The authors declare no conflict of interest.

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