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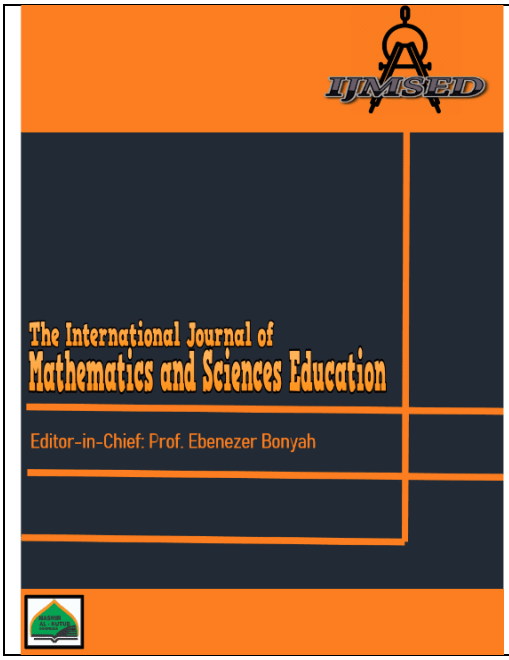

Conceptual understanding and misconceptions of the human digestive system in elementary school: insights from a four-tier diagnostic test

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Conceptual understanding and misconceptions of the human digestive system in elementary school: insights from a four-tier diagnostic test

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Abstract
The purpose of this study was to analyze the form and level of misconceptions of fifth grade elementary school students on the material of the human digestive system with the Four-Tier Diagnostic Test instrument. A descriptive quantitative method was used and with a quantitative approach. The Four-Tier Diagnostic Test was used to identify misconceptions in more depth by analyzing students' answers, reasons, and level of confidence in the answers given. This study involved 27 students of class V A of Djama'atul Ichwan Elementary School in Surakarta, Central Java, Indonesia who were purposely selected. The results of the analysis show that the overall misconceptions of students are at a level of 18% which means that the level of misconception is low, but still in each specific sub-concept there are misconceptions, the highest misconceptions are found in several items on the sub-material of digestive organs and their functions with a percentage of item misconceptions of 37%. This research suggests that conceptual diagnosis-based learning methodologies and contextual learning media, like augmented reality media and practical kits, are necessary to reduce misconceptions. This research also confirms that the Four-Tier Diagnostic Test is an effective diagnostic tool for detecting science misconceptions at the primary school level.

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1. Introduction

Science is one of the school subjects that plays a very important role in constructing students' knowledge from elementary school level. The material taught in this subject, including the human digestive system, aims to provide conceptual and practical understanding of the scientific processes that occur in the human body (Agustina et al., 2024). The material on the human digestive covers topics such as digestive organs and their functions (mouth, esophagus, stomach, intestines, and anus), mechanical and chemical digestion processes, nutrients in food and their benefits for the body, and disorders of the digestive system (Mahmudah, 2023; Milawati et al., 2022). This material is very relevant to the daily lives of students, especially regarding diet and healthy lifestyles.

Teachers in elementary schools who teach science must be able to provide their students with an understanding of the concepts and benefits of science in everyday life. Before starting science lessons in class, teachers will ask questions to spark discussion and open up the lesson. This is to find out what initial concepts the students have about the material that will be presented by the teacher (Arif et al., 2024). The initial concepts that students have before the teacher delivers the material may be correct or incorrect. Students obtain their initial concepts from their own experiences and from various sources of information that may be inaccurate. However, the initial concepts that students understand greatly influence their acquisition of knowledge in the classroom (Wirastuti & J., 2023).

However in reality, students often have misconceptions, which are understandings that deviate from agreed-upon scientific concepts. Misconceptions are incorrect understandings that students believe

to be true. These understandings are often formed early on due to a lack of personal experience, information from the media, or inaccurate explanations from teachers (Indrajatun & Destya, 2022; Pakpahan et al., 2020). In the context of science learning, misconceptions can hinder the formation of comprehensive scientific concepts and will have an impact on students' difficulty in understanding subsequent material (Sirajudin et al., 2022). Research by Dewi et al. (2021) shows that misconceptions occur not only because of student factors, but also because teachers do not thoroughly evaluate students' prior understanding before learning takes place. For educators, this poses a challenge, because if misconceptions are not addressed immediately, they will hinder students' further understanding.

To identify misconceptions in depth, instruments that are capable of digging deeper than just right or wrong answers. One effective method for identifying misconceptions is the Four-Tier Diagnostic Test, which is specially designed to evaluate students' answer, reason, and level of confidence in the answers and reasons they provide (Sirajudin et al., 2022). This method has been widely applied in previous studies with the aim of analyzing students' misconceptions on various science subjects (Ismi et al., 2020; Mahmudah, 2023). In human digestive system material, this method helps identify which parts of the digestive process are most often misunderstood, such as the names of digestive organs, digestive system processes, nutrients in food, and digestive system disorders.

Mahmudah's (2023) research found that around 88,82% of students had misconceptions about the human digestive system. The most commonly misunderstood sub-concept was the chemical digestion process that occurs in the small intestine and stomach, which is often considered to be the same or the difference between the two is unknown. This is reinforced by research by Milawati et al. (2022), which emphasizes the importance of using concrete media such as human body torso models to help students understand the structure and function of organs visually. In addition, Samsu (2021) states that teachers need to develop a learning approach based on the diagnosis of learning difficulties so that the process of correcting misconceptions can be carried out in a targeted, efficient, and sustainable manner.

While previous studies have identified misconceptions on the same topics, this study aims to address a distinct research gap. Mahmudah's (2023) research reported a very high overall misconceptions percentage (88,92%) whereas Milawati et al. (2022) focused more on solution-based media use. This present study seeks to provide a more granular and in-depth analysis of the specific forms of misconceptions within each sub-topic, moving beyond mere percentage quantification. By employing the Four-Tier Diagnostic Test, which reveals the confidence and reasoning behind students' answers, this research focuses on detailing the nature of conceptual errors within a specific primary school context, thereby offering a distinct contribution to the diagnostic literature.

To guide the investigation, this research aims to answer the following questions:

a. What are the forms and overall evell of misconceptions among fifth-grade students regarding the human digestive system material?
b. Which specific sub-concept exhibits the highest level of misconceptios based on Four-Tier Diagnostic Test results?
c. What are the possible underlying factors contributing to these indentified misconceptions?

This research was conducted in Class V A of Djama'atul Ichwan Elementary School, Surakarta, based on purposive sampling considerations. The fifth grade was specially chosen because the national curriculum designates the human digestive system as compulsory subject matter at this level, ensuring that students have received complete instruction on the topic. Djama'atul Ichwan Elementary School was selected as it represents a private urban elementary school with a diverse student population and provided excellent access and cooperation for in-depth diagnostic data collection. Class V A was chosen as the sample due to teacher's readiness and the class's homogenity in receiving the subject matter, which allowed for the analysis of misconceptions without significant confounding variables.

Based on this background, this study focuses on analyzing the forms and level of conceptual errors or misconceptions among fifth-grade elementary school students in understanding human digestive system material using the Four-Tier Diagnostic Test method. By identifying the types of misconceptions that occur, teachers can develop more effective learning approaches, both in terms of material delivery and the selection of learning media. It is hoped that the results of this study will be useful as review material in efforts to improve the quality of science learning at the elementary school level, particularly in forming correct concepts from an early age.

2. Method

2.1 Research Design

The method used in this study was a quantitative descriptive approach, which aimed to analyze students' misconceptions about the human digestive system. The quantitative descriptive approach allowed researchers to describe phenomena systematically and objectively based on numerical data obtained from research instrument (Dovetail, 2023).

2.2 Participants

The research was conducted at SD Djama'atul Ichwan in the 2024/2025 academic year. This school is located at Jl. K.H. Agus Salim No. 45, Sondakan, Laweyan, Surakarta, Central Java. The subjects of this study were 27 fifth-grade students in class A. The sampling technique employed was purposive sampling. This method was chosen because the research required participants with specific characteristics crucial to the study objectives, namely students who had received complete formal instruction on the human digestive system according to the fifth-grade science curriculum. The primary criteria for selecting Class V A were: (1) the class had fully covered the target learning material, ensuring identified misconceptions were not due to a lack of content exposure; (2) the classroom was highly cooperative and facilitated the smooth administration of the diagnostic test; and (3) the school setting provided a representative context for in-depth case study on science misconceptions at the primary level.

This study adhered to standard ethical research principles involving human subjects. Formal approval was obtained from the school principal and the class teacher prior to data collection. Informed consent was secured from the parents or guardians of all participating students, outlining the study's purpose, procedures and the anonymous use of the data for academic analysis. Students were also verbally obtained on the day of testing, ensuring their voluntary participation. Confidence was maintained by anonymizing all student data; no personal identifiers were used in data analysis or reporting. The Four-Tier Diagnostic Test was administered as a regular classroom activity to minimize anxiety, and the results were used solely for diagnostic and research purposes, aligning with the school's educational objectives.

2.3 Data Collection

The data in this study includes primary data collected directly from research subjects through written test. The instrument used in the written test was the Four-Tier Test, which was used to identify the extent of students' conceptual understanding of the human digestive system. This instrument consists of four levels of confidence: (1) multiple-choice questions about the concepts of the digestive system (2) level of confidence in the answers, (3) reasons underlying the answers, (4) level of confidence in the reasons. The use of the Four-Tier Test has been proven effective in evaluating not only the answers given but also the reasons and the level of confidence of students in the answers given (Prayitno & Hidayati, 2022).

The diagnostic test instrument consists of 20 questions on the human digestive system material, divided into 4 sub-concepts. There are 5 questions on the digestive organs and their functions sub-concepts, 3 questions on the human digestive process sub-concept, 9 questions on nutrition in food and its functions, and 3 questions on digestive system disorders sub-concept. An example of a test item can be seen in Figure 1.

Figure 1
Example of a Four-Tier Test Diagnostic question item

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1. 1) Perhatikan organ berikut!
(1) mulut
(2) tenggorokan
(3) kerongkongan
(4) jantung
(5) lambung
Organ-organ pencernaan manusia ditunjukkan oleh pernyataan nomor...
a. 1, 2, dan 5
b. 1, 2, dan 4
c. 1, 3, dan 4
d. 1, 3, dan 5
2) Apakah kamu yakin dengan jawabanmu?
a. Yakin b. Tidak yakin
3) Alasan:
4) Apakah kau yakin dengan alasan yang kamu tulis?
a. Yakin b. Tidak yakin

Figure 1 shows that there are 4 levels of questions, including (1) multiple-choice questions about the concepts of the digestive system (2) level of confidence in the answers, (3) reasons underlying the answers, (4) level of confidence in the reasons.

2.4 Data Analysis

Data collection was carried out on April 30, 2025 with a duration of 90 minutes. The number of students who took this test was 27. The data analysis technique performed was to group the students' diagnostic test results into several categories, as shown in Table 1.

Table 1
Interpretation table for Four-Tier Diagnostic Test results

Answer	Confidence in answers	Reason	Belief in reason	Category
True	Sure	True	Sure	Scientific conception
True	Sure	True	Not sure	Lack of knowledge
True	Sure	False	Not sure	Lack of knowledge
True	Not sure	True	Sure	Lack of knowledge
True	Not sure	True	Not sure	Lack of knowledge
True	Not sure	False	Not sure	Lack of knowledge
False	Sure	True	Not sure	Lack of knowledge
False	Sure	False	Not sure	Lack of knowledge
False	Not sure	True	Not sure	Lack of knowledge
False	Not sure	False	Not sure	Lack of knowledge
True	Sure	False	Sure	Misconception
True	Not sure	False	Sure	Misconception
False	Sure	False	Sure	Misconception
False	Not sure	False	Sure	Misconception
False	Sure	True	Sure	Error
False	Not sure	True	Sure	Error

After grouping based on categories in Table 1, the percentage of students who understood the concept, does not understood the concepts, had misconceptions, and made errors was calculated using the formula formulated by Sudijono (2015) in Sukarjita et al. (2023) As shown in Equation (1).

$$P = \frac{f}{N} \, x \, 100\% \qquad (1)$$

P is the percentage of students in the criteria, f is the frequency of students who answered within the criteria, and N is the total number of students. Next, categorize the results of the Four-Tier Diagnostic Test and calculate the percentage of students' misconceptions based on the categories of misconceptions by Minarni et al. (2018) as follows.

00% < Misconceptions ≤ 30% : low misconception category
30% < Misconceptions ≤ 70% : moderate misconception category
70% < Misconceptions ≤ 100% : high misconception category

3. Results and Discussion

3.1 Results

Misconceptions about the human digestive system in science education were identified using a Four-Tier Diagnostic Test administered to fifth-grade elementary school students. The results of the Four-Tier Diagnostic Test and the grouping of items into various categories are shown in Table 2.

Table 2
Results of the Four-Tier Diagnostic Test

Sub-concepts	No	Understood the concepts		Does not understood the concepts		Misconception		Error	
Digestive organs and functions	1	9	33%	10	37%	8	30%	0	0%
Digestive organs and functions	2	19	70%	6	22%	2	7%	0	0%
Digestive organs and functions	3	9	33%	8	30%	10	37%	0	0%
Digestive organs and functions	4	8	30%	8	30%	10	37%	1	4%
Digestive organs and functions	5	8	30%	12	44%	6	22%	1	4%
The human digestive process	6	13	48%	9	33%	3	11%	2	7%
The human digestive process	7	6	22%	11	41%	6	22%	4	15%
The human digestive process	8	16	59%	9	33%	2	7%	0	0%
Nutrient in food and functions	9	16	59%	4	15%	4	15%	3	11%
Nutrient in food and functions	10	20	74%	3	11%	4	15%	0	0%
Nutrient in food and functions	11	14	52%	9	33%	4	15%	0	0%
Nutrient in food and functions	13	7	26%	14	52%	6	22%	0	0%
Nutrient in food and functions	14	3	11%	17	63%	7	26%	0	0%
Nutrient in food and functions	17	19	70%	5	19%	3	11%	0	0%
Nutrient in food and functions	18	2	7%	16	59%	8	30%	1	4%
Nutrient in food and functions	19	12	44%	13	48%	1	4%	1	4%
Nutrient in food and functions	20	8	30%	18	67%	1	4%	0	0%
Digestive system disorders	12	8	30%	10	37%	8	30%	1	4%
Digestive system disorders	15	13	48%	13	48%	1	4%	0	0%
Digestive system disorders	16	10	37%	14	52%	3	11%	0	0%
Total		220	815	209	774	97	359	14	52
Average		20,95	41%	19,90	39%	9,24	18%	1,34	3%

The results for the sub-concept of digestive organs and their functions reveal a generally uneven level of conceptual understanding among students. Across items 1 to 5, the proportion of students who correctly understood the concepts fluctuates between 30% and 70%, indicating inconsistent mastery. Items 2 shows relatively strong understanding (70%), suggesting that certain aspects of digestive organ functions are more accessible or frequently reinforced in instruction. However, items 1, 3, 4, and 5 show that fewer than one-third of students fully understood the concepts, while misconceptions and lack of understanding together exceed 60% in several cases. This pattern suggests that students may recognize organ names but struggle to accurately connect structure with function. The presence of misconceptions, reaching up to 37% in some items, indicates not merely a lack of knowledge but the existence of alternative conceptions that may interfere with learning. Overall, this sub-concept reflects foundational weaknesses that could hinder students' understanding of more complex digestive processes.

Findings related to the human digestive process (items 6–8) indicate moderate conceptual understanding, but with notable conceptual fragility. While item 8 shows a relatively high percentage of

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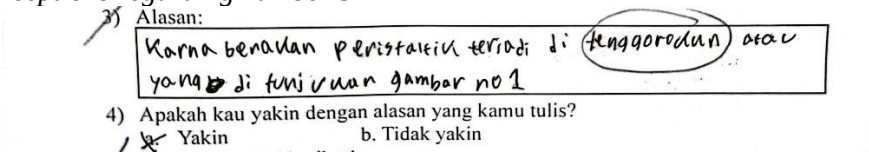
correct understanding (59%), items 6 and 7 reveal that more than half of the students either did not understand the concept or held misconceptions. Item 7 is particularly concerning, with only 22% of students demonstrating correct understanding and 15% committing procedural or conceptual errors, the highest error rate within this sub-concept. These results suggest that sequential and dynamic aspects of digestion—such as enzymatic actions and food transformation—pose greater cognitive challenges than static knowledge of organs. The coexistence of misconceptions and errors implies confusion not only at the conceptual level but also in applying knowledge logically. This indicates that instructional approaches may insufficiently emphasize process-based reasoning, visualization, or causal explanations, which are critical for understanding biological systems.

The most pronounced difficulties appear in the sub-concept of nutrients in food and their functions, as well as digestive system disorders. Several items (13, 14, 18, and 20) show extremely low levels of correct understanding, ranging from 7% to 30%, while more than half of the students demonstrate lack of understanding. Misconceptions remain substantial, particularly in item 18 (30%), suggesting confusion about nutrient roles or classification. Although some items (10 and 17) reflect strong understanding (above 70%), the overall pattern indicates fragmented knowledge rather than coherent conceptual frameworks. Similarly, in digestive system disorders, understanding rarely exceeds 48%, with many students unable to distinguish between symptoms, causes, and mechanisms. The overall averages reinforce this concern: only 41% of responses reflect correct understanding, while 39% indicate lack of understanding and 18% misconceptions. This highlights the urgent need for instructional strategies that explicitly address misconceptions and integrate concepts meaningfully rather than emphasizing rote learning.

Based on Table 2, the most common misconceptions among students were found in questions number 3 and 4, with the sub-concept of digestive organs and functions reaching a misconceptions rate of 37%. The forms of misconception can be seen in Figure 2 and Figure 3.

Figure 2

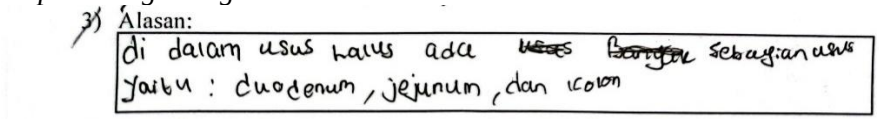
Misconceptions regarding number 3



Based on Figure 2, it is known that the misconception is question number 3 lies in the students' understanding of the names of the digestive system organs. Furthermore, the misconception in question number 4 is shown in Figure 3.

Figure 3

Misconceptions regarding number 4



Based on Figure 3, the misconception in question number 4 is the students' knowledge of the small intestine as part of the digestive system.

3.2 Discussion

The analysis results using the Four-Tier Diagnostic Test revealed that the students in class VA of SD Djama'atul Ichwan experienced various misconceptions regarding the human digestive system material. One of the most common misconceptions about the names and functions of organs in the digestive system. As in question number 3, students answered that peristaltic movement occurs in the throat, whereas scientifically the intended organ should be the esophagus. Next, in question number 4, the students answered that the colon is part of the small intestine, when in fact, the parts of the small intestine are the duodenum, jejunum, and ileum. This misconception indicates a misunderstanding of the parts of the human digestive system.

The analysis using the Four-Tier Diagnostic Test revealed that the fifth-grade students in this study exhibited a low overall level of misconceptions (18%) regarding the human digestive system. This finding presents a striking contrast to the study by Mahmudah (2023), which reported a very high

misconception rate of 88,82% on similar material. This significant discrepancy can likely be attributed to key methodological and contextual differences. Mahmudah's (2023) study utilized a Four-Tier test combined with the Certainty of Response Index (CRI), potentially capturing a broader spectrum of uncertainty as misconception. Furthermore, differences in student demographics, prior instructional quality, textbook usage, and the specific diagnostic items can dramatically influence outcomes. The presents study's lower aggregate percentage suggests that while foundation understanding might be present, critical conceptual errors persist in specific areas and require targeted intervention, rather than indicating a wholesale lack of knowledge.

The data pinpoint that the sub-concept of digestive organs and their functions was the most problematic, with specific items reaching a 37% misconception rate. This aligns with broader findings in science education where anatomical structures and their physiological roles are challenging for young learners (Ambarita & Rusyati, 2025). The identified errors, confusing the esophagus with the throat, and misunderstanding the parts of the intestines, are not mere factual slips. They indicate a fragile, non-systemic mental model of the digestive tract. Students might perceive it as a simple "tube" rather than a specialized series of organs with distinct functions. This can stem from rote memorization of names without grasping the sequential, functional journey of food, exacerbated by static, two-dimensional diagrams commonly used in textbooks that fail to convey dynamic processes.

The use of the Four-Tier Diagnostic Test has proven effective in deeply identifying students' misconceptions. This instrument not only assesses students' answers but also the reasoning behind those answers, along with the students' confidence level, distinguishing between those who truly understand the concepts and those who answer correctly by chance (Kartimi et al., 2021). Additionally, research by Prastyo et al. (2024) indicates that the Four-Tier Diagnostic Test can reveal misconceptions not detected by traditional evaluation instruments. Thus, using this instrument can make it easier for teachers to design various learning strategy innovations that are more effective in overcoming students' misconceptions.

Factors contributing to misconceptions include the use of inaccurate textbooks, a lack of varied teaching methods, and students' limited experience with the objects or phenomena being studied. Therefore, it is important for educators to use various learning resources and teaching methods that can help students build a correct understanding, such as the use of visual media, simulations, and simple experiments relevant to everyday life (Atmojo et al., 2024).

The educational implications of these findings are direct and actionable. To remediate such deep-seated confusions, teachers must move beyond traditional lecture methods. Conceptual change strategies are essential. Techniques like Predict-Observe-Explain (POE) using simulations of peristalsis, or cognitive conflict through targeted refutational texts that explicitly state and then dismantle common errors (e.g., "Some think the colon is part of the small intestine, but actually…"), can effectively disrupt misconceptions. Furthermore, the use of interactive, contextual media is critical. Augmented reality (AR) applications that allow students to "walk through" a 3D digestive system, or hands-on models using everyday materials to simulate digestion, can build accurate mental models by making abstract processes concrete and visually dynamic.

The limitations of this study must be acknowledged to contextualize its findings. The research involved a relatively small sample size (n=27) from a single class in a single school. While purposive sampling allowed for deep diagnostic analysis, this limits the generalizability of the results to the wider population of fifth-grade students. The study provides a detailed, contextual snapshot rather than a broad epidemiological view of misconceptions. Future research should aim for a larger, more diverse sample across multiple schools and regions to validate and extend these findings.

From a theoretical perspective, these findings contribute to the understanding of misconception structure. The fact that students could score well overall yet harbor significant, confident errors in specific sub-concepts underscores that scientific understanding is not monolithic. It supports the theory that knowledge is compartmentalized and that misconceptions can coexist with correct knowledge in different domains. The study reinforces the need for diagnostic tools capable of mapping this nuanced landscape, as aggregate scores can mask specific, critical learning gaps.

Finally, this research provides clear evidence for the superior effectiveness of the Four-Tier Diagnostic Test over traditional assessment tools. A coventional multiple-choice test might have flagged items 3 and 4 as merely "incorrect". However, the Four-Tier structure, by isolating the reason and the

confidence level, allowed us to diagnose these errors specifically as misconceptions rather than as guesses or lack of knowledge. This precise diagnostic information, as advocated by Prastyo et al. (2024), is what empowers educators to move from knowing that a student is wrong to understanding why they are wrong, enabling the design of precisely targeted remedial instruction. Thus, the science learning process in elementary school can be more effective in building correct conceptual understanding when informed by such nuanced diagnostic insights. The imperative for teacher professional development is clear: equipping educators with the skills to utilize diagnostic instruments like the Four-Tier test and to implement consequent conceptual change strategies is vital for meaningful science education reform.

4. Conclusion

This study concludes that while the overall level of misconceptions among fifth-grade students on the human digestive system material is low (18%), significant and deeply held misconceptions persist within specific sub-concepts, most prominently in digestive organs and their functions, where items reached 37%. This indicates a fragmented student understanding, where correct knowledge coexists with confident errors about organ roles and structures, such as confusing the esophagus with the throat or misidentifying intestinal parts. Theoretically, this reinforces the necessity of diagnostic tools that map the nuanced architecture of student thinking beyond aggregate scores.

Based on these findings, specific recommendations are proposed: for teacher, to implement targeted conceptual change strategies like Predict-Observe-Explain (POE) and contextual media such as 3D simulation focusing on high-misconception topics; for curriculum developers and textbook authors, to embed alerts for common misconceptions and design dynamic, functionally explanatory diagrams; and for future research, to pursue studies with larger, more diverse samples, experimental or longitudinal designs, and the development of a standardized diagnostic test bank to validate interventions and deepen the understanding of misconception formation and remediation.

Limitations

While the study provides valuable insights, several limitations must be acknowledged. First, the findings are based on a small sample size (n=27) from a single class in one elementary school (SD Djama'atul Ichwan Surakarta). This limits the statistical generalizability of the results to the broader population of fifth-grade students in Indonesia. Second, the study employed a descriptive quantitative design with a one-time test administration. This provides a snapshot of misconceptions but cannot trace their origins or determinate causal relationships between teaching methods and conceptual understanding. Third, although the Four-Tier Diagnostic Test is robust, the specific instrument was contextual to one school's curriculum, and its items may not capture every possible misconception variant.

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Author Contribution

Author 1: Conceptualization, Writing - Original Draft, Editing and Visualization, Writing - Review & Editing, Formal analysis, and Methodology;

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Conflict of Interest

The authors declare no conflict of interest.

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