

Identifying Misconceptions on Earth and Solar System Concepts Among Junior High School Students Using a Four-Tier Diagnostic Test

Annaya Keisa Fasya*, Lilit Rusyati, and Nuryani Y. Rustaman

International Program on Science Education, Universitas Pendidikan Indonesia, Bandung,
Indonesia

*annayakeisyafasya@upi.edu

Article Info	Abstract
Article history: Received: April 22, 2025 Accepted: June 18, 2025 Published: July 10, 2025 Keywords: Earth and the solar system Four-tier diagnostic test Misconceptions This article is licensed under a Creative Commons Attribution-NonCommercial- NoDerivatives 4.0 International License © 2025 Berkala ilmiah Pendidikan Fisika	This study uses a quantitative method with a cross-sectional survey design to identify students' misconceptions about Earth and the solar system. Data were collected from 8th-grade students in West Bandung using a four-tier diagnostic test. This study investigates misconceptions about Earth and the solar system among junior high school students in West Bandung using a four-tier diagnostic test. The study aims to identify the types and causes of students' misconceptions and determine subtopics with the highest misconception rates. A quantitative approach, employing a cross-sectional survey design, was used to investigate the study, involving 509 eighth-grade students from 17 schools. The four-tier diagnostic test consisted of multiple-choice items integrated with confidence ratings and reasoning justifications. Students' responses were categorized into five diagnostic levels: Scientific Knowledge (SK), Misconception (M), False Positive (FP), False Negative (FN), and Lack of Knowledge (LK). Descriptive statistical analysis was conducted to calculate the percentage distribution across these categories for each item and subtopic. In addition, item analysis techniques such as difficulty index, discrimination index, and reliability testing using Cronbach's Alpha were applied to ensure the quality and consistency of the instrument. A total of 32.61% of students had low understanding, 20.94% had misconceptions, and only 24.84% had scientific understanding. These results indicate the need for improved teaching methods to reduce student misconceptions. The study recommends applying the four-tier diagnostic test after students have studied the topic for optimal results. Clear, simple language in test items is essential to avoid confusion. Teachers should utilize visualization-based methods, such as 3D models and animations, to explain abstract concepts related to the Earth and solar system. Teachers' mastery of the topic is crucial to prevent student misconceptions.
To cite this article: Fasya, A. K, Rusyati, L., & Rustaman, N. Y. (2025). Identifying misconceptions on earth and solar system concepts among junior high school students using a four-tier diagnostic test. <i>Berkala Ilmiah Pendidikan Fisika</i>, 13(2), 292-308.	

INTRODUCTION

Concept understanding in science learning depends not only on the knowledge received formally at school but also on students' ability to relate new information to previous experiences and knowledge. This process is crucial as students learn by integrating new material with what they already know from formal learning and everyday experiences.

However, connecting new concepts with old understandings often challenges the learning process ([Sevgi & Karakaya, 2020](#); [Widiyatmoko & Shimizu, 2018](#)). The mismatch between students' understanding and correct scientific concepts leads to the emergence of misconceptions, which are false understandings that students believe to be true. These misconceptions can come from personal experiences, wrong interpretations, or inappropriate learning sources. Misconceptions tend to last long and become obstacles in learning further scientific concepts ([Duda & Adpriyadi, 2020](#)).

The impact of misconceptions in science learning is significant because it can hinder students' understanding of scientific phenomena and the necessary critical thinking process. Misconceptions are difficult to eliminate if not immediately recognized and addressed appropriately, so it is very important to identify misconceptions early so that learning can run effectively and correctly ([Dewi & Wulandari, 2021](#); [Soeharto et al., 2019](#)). In the context of science education, teachers have an important role not only in explaining concepts correctly but also in detecting and addressing misconceptions that exist in students. The first step that must be taken is to identify misconceptions precisely and in depth so that the learning interventions provided can adjust to the needs of students ([Gurel et al., 2015](#); [Köseoğlu & Özkanbaş, 2023](#)).

One effective tool to accurately identify misconceptions is the four-tier diagnostic test. This instrument consists of four levels of questions that measure students' answers, the reasoning behind those answers, and students' level of confidence in their answers and reasoning. This approach allows for the recognition of misconceptions with a higher level of precision than other diagnostic methods, such as traditional multiple choice ([Kiray & Simsek, 2020](#); [Tumanggor et al., 2020](#)).

The topic of Earth and the solar system is fundamental in the science curriculum and crucial for developing students' scientific literacy. However, it is especially prone to misconceptions due to its abstract and non-observable nature. Students often struggle with concepts such as planetary motion, the cause of day and night, and the position of celestial bodies because these ideas conflict with everyday experiences and intuitive reasoning ([Kaltakci-Gurel et al., 2017](#); [Trundle & Troland, 2005](#)). The lack of a dedicated astronomy subject further limits students' conceptual understanding ([Azizah et al., 2022](#)). Studies have shown that without proper visualization and explanation, misconceptions persist and can hinder future learning. A meta-analysis of 35 studies confirmed the widespread nature of these misconceptions, emphasizing the need for targeted instructional interventions ([Mellu & Baok, 2020](#)).

The studies show how well the four-tier diagnostic tool works to spot student misconceptions on a range of biological topics, such as plant reproduction, human excretion, and the circulatory system. These results demonstrate how common misconceptions are among students and emphasize how crucial it is to use focused teaching techniques to dispel them. The four-tier diagnostic test has been used consistently in various research, indicating its wider usefulness in science education to enhance learning outcomes and conceptual understanding ([Ambarita & Rusyati, 2025](#); [Saputri & Rusyati, 2024](#); [Amelia et al., 2023](#)).

This research was conducted in the West Bandung region, an area with a diverse social, economic, and academic background among its students. This diversity provides an opportunity to obtain more complete and in-depth data related to the forms of misconceptions experienced by students in various educational backgrounds. Therefore, West Bandung was chosen as a strategic location to study the effectiveness of science education, especially in Earth and Solar System materials ([Amalia et al., 2016](#); [Nasyidiah et al., 2020](#)).

Based on this background, this study aims to analyze students' understanding of Earth and Solar System material in the West Bandung area, as determined by the results of a four-tier diagnostic test analysis, and identify subtopics in Earth and Solar System material that

have the highest level of misconceptions among students. Thus, the results of this study are expected to provide a clear picture of the level of understanding and misconceptions of students so that it can be used as a basis for developing learning strategies that are more effective and in accordance with the needs of students.

METHODS

This quantitative research uses a cross-sectional survey design that aims to explore students' understanding of science concepts at one specific time. Quantitative research has systematic, organized, methodical, and transparent characteristics from start to finish and is more resilient in dealing with field conditions ([Kandel, 2020](#)). In the context of education, the survey design is a method that is carried out without manipulation of variables or special treatment of the sample. The instrument used is a four-tier diagnostic test developed through three stages: preparation, implementation, and completion stages, to ensure validity and accuracy in detecting student misconceptions.

This quantitative research employed a cross-sectional survey design to explore students' understanding of science concepts at a specific point in time. A total of 509 eighth-grade students from 17 junior high schools in West Bandung participated in the study. The schools and participants were selected using convenience sampling, focusing on accessible schools that had already covered the Earth and Solar System topic based on the curriculum. The four-tier diagnostic test was administered after instruction was completed to ensure that students had prior exposure to the material.

The instrument was developed in three stages: (1) the preparation stage, where open-ended questions were designed based on key concepts and common misconceptions from literature; (2) the implementation stage, where student responses were analyzed and transformed into four-tier multiple-choice items, then validated through expert review; and (3) the completion stage, involving pilot testing with 44 students to refine the items. Content validity was established through expert judgment, while statistical validation involved item analysis, including difficulty and discrimination indices. The reliability of the instrument was measured using Cronbach's alpha, which showed satisfactory internal consistency across test items.

Preparation Stage

At this stage, the preparation of research instruments was carried out. The development of research instruments began with a preliminary study conducted on grade VIII students who had previously studied the topic of Earth and the Solar System. At this stage, 14 open-ended questions were given through Google Forms to capture students' initial understanding of each subtopic. The answers were then organized and developed into a four-tier diagnostic test that included questions at the cognitive level, the reason for choosing the answer, and the level of confidence in the answer and reasoning. This format allowed the researcher to gain a deeper understanding of students' concepts and their confidence levels. The instrument was developed not only based on students' answers but also referred to learning materials and expert reviews to ensure the appropriateness and accuracy of the content.

To measure the quality of the test instrument, a content validity test was conducted involving three experts, consisting of lecturers and science teachers. Validation was analyzed using Aiken's V formula ([Muliana et al., 2020](#)) to determine the level of agreement of experts on the relevance of each item. Aiken's V coefficient helps assess whether the questions developed are in accordance with the desired content and learning objectives. This validation process ensures that the instruments used are appropriate, relevant, and valid for diagnosing student misconceptions. The results of the validation of each item are presented in Table 1.

Table 1 Aiken test for validation results

Item	Expert			S ₁	S ₂	S ₃	Σs	n(c-1)	V	Validity
	I	II	III							
1	1	1	1	1	1	1	3	3	1.00	High
2	1	1	1	1	1	1	3	3	1.00	High
3	1	1	0	1	1	0	2	3	0.67	Moderate
4	1	1	0	1	1	0	2	3	0.67	Moderate
5	1	0	0	1	0	0	1	3	0.33	Low
6	1	1	1	1	1	1	3	3	1.00	High
7	1	1	1	1	1	1	3	3	1.00	High
8	1	0	1	1	0	1	2	3	0.67	Moderate
9	1	1	1	1	1	1	3	3	1.00	High
10	1	1	1	1	1	1	3	3	1.00	High
11	1	1	1	1	1	1	3	3	1.00	High
12	1	1	1	1	1	1	3	3	1.00	High
13	1	1	1	1	1	1	3	3	1.00	High
14	1	1	1	1	1	1	3	3	1.00	High
Average: 0.88 (High Category)										

Aiken's test results have a criterion of ≥ 0.8 . Index values above 0.8 indicate high validity, while values between 0.4 and 0.8 indicate moderate validity. If the value is below 0.4, the item is considered invalid, even though it is statistically significant (Muliana et al., 2020). Based on the results in Table 1, the coefficient V value on each test item obtained a value with an average of 0.88, so that this test item is included in the high category. After expert validation, the questions were revised and tested on grade 9 students. Instrument validation was conducted using Rasch model analysis, which helps evaluate item quality and measurement accuracy. This model offers a strong background framework for assessing instrument reliability and validity (Darmana et al., 2024). The validity criteria are presented in Table 2.

Table 2 Result of validation test

Item	Tier	OUTFIT MNSQ	OUTFIT ZSTD	PTMEASUR-AL CORR	Interpretation	Decision
Q1	1	1.06	1.27	0.22	Not Valid	Not Used
	3	0.94	-0.39	0.39		
Q2	1	0.77	-0.85	0.42	Valid	Used
	3	0.75	-1.45	0.47		
Q3	1	0.86	-0.01	0.42	Valid	Used
	3	1.07	0.36	0.13		
Q4	1	0.92	0.28	0.44	Valid	Used
	3	1.02	0.23	0.3		
Q5	1	1.02	0.15	0.28	Not Valid	Not Used
	3	0.94	-0.29	0.39		
Q6	1	0.92	-0.61	0.43	Valid	Used
	3	1.11	0.45	0.31		
Q7	1	1.2	0.55	0.07	Not Valid	Not Used
	3	0.9	-0.22	0.28		
Q8	1	1.14	1.27	0.15	Valid	Used
	3	1.05	0.5	0.28		
Q9	1	1.13	0.39	0.21	Valid	Used
	3	0.88	0.88	0.49		
Q10	1	1	0.03	0.29	Valid	Used
	3	1.2	1.78	0.09		
Q11	1	0.84	-1.17	0.73	Valid	Used
	3	1.07	0.43	0.58		
Q12	1	0.90	-0.58	0.70	Valid	Used
	3	0.95	-0.30	0.65		

Item	Tier	OUTFIT MNSQ	OUTFIT ZSTD	PTMEASUR-AL CORR	Interpretation	Decision
Q13	1 3	1.03 1.02	0.3 0.24	0.28 0.27	Valid	Used
Q14	1 3	1.26 0.97	1.84 -0.06	0.56 0.68	Valid	Used

The criteria for questions are declared valid if they meet three criteria: the MNSQ value is between 0.5 and 1.5, the ZSTD is between -2.0 and +2.0, and the point measure correlation ranges from 0.4 to 0.85. In the instrument validation process, 47 junior high school students were involved as research samples. Based on the analysis results shown in Table 2, 12 out of 14 questions proved to meet these criteria and were declared valid at level 1 and level 3. Furthermore, reliability tests are conducted to assess the consistency of the rater's response to an item in the research instrument ([Avinç & Doğan, 2024](#)), so that the data obtained is accurate and valid. This test is only carried out on valid questions. Reliability test results can be seen in Table 3.

Table 3 Reliability results from validation questions

Tier	Item Reliability	Criteria
1	0.88	Very High
3	0.92	Very High

The reliability level criteria are divided into five categories, ranging from very low to very high based on their index values ([Darmana et al., 2024](#)). To be acceptable, rater and item reliabilities should be more than 0.50 ([Avinç & Doğan, 2024](#)). The reliability test results at levels 1 and 3 showed very high values (0.88 and 0.92), indicating that this instrument is highly reliable and suitable for measuring participants' abilities ([Ridzuan et al., 2020](#)).

Implementation Stage

This research sample focuses on junior high schools in the West Region of Bandung City that have already implemented the *Kurikulum Merdeka*. Figure 1 shows a map listing schools in Bandung City.

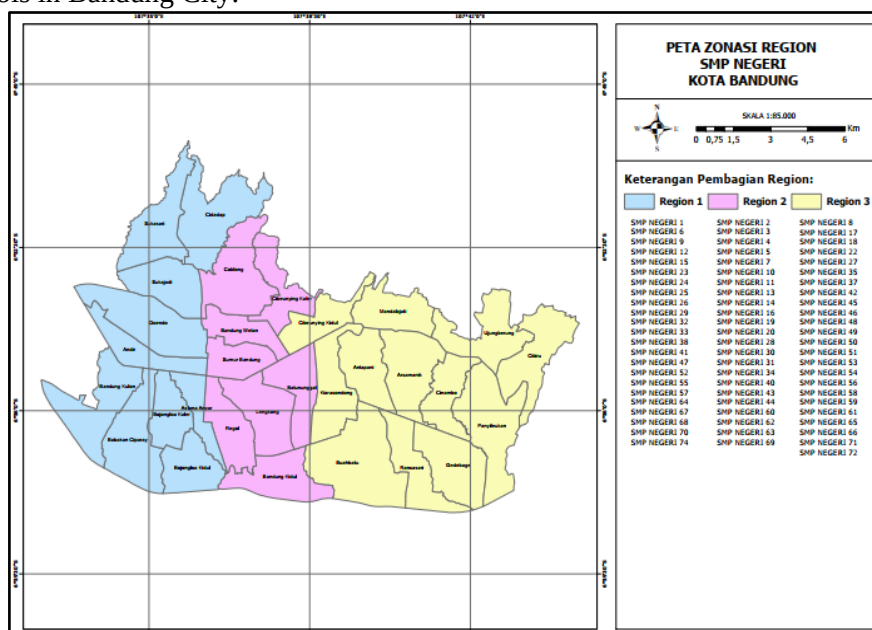


Figure 1 Map list of schools in bandung city

Data collection was conducted in Region 1, specifically in the West Bandung area, with a focus on grade 8 students who had studied material related to the Earth and the solar system. The convenience sampling technique was employed by selecting a sample that was readily accessible. Although generalization from this sample requires random sampling within the population for the results to be valid ([Andrade, 2021](#)), this method was chosen due to its practicality, low cost, and efficiency. Of the 22 targeted schools, 17 were willing to participate in data collection.

Completion Stage

A descriptive statistical analysis was carried out to provide an overview of the collected data. In a four-level diagnostic test, student responses are categorized into five types, namely Scientific Knowledge (SK), Misconception (M), False Positive (FP), False Negative (FN), and Lack of Knowledge (LK) ([Kiray & Simsek, 2021](#)), as can be seen in Table 4.

Table 4 The Decisions of the Four-Tier Test

1 st Tier	2 nd Tier	3 rd Tier	4 th Tier	The decision of the Four-Tier Test
True	Sure	True	Sure	SK
True	Sure	False	Sure	FP
False	Sure	True	Sure	FN
False	Sure	False	Sure	M
True/False	Sure/Not Sure	True/False	Sure/Not Sure	LK

The answer data obtained was then entered into Excel to determine the type of student conception with a score of “1” for correct answers and “0” for incorrect answers, including questions related to the level of confidence in answering, which was also assessed with a similar score ([Kiray & Simsek, 2021](#)).

RESULTS AND DISCUSSION

This chapter presents the analysis results of responses from 509 eighth-grade students from 17 junior high schools in West Bandung Regency on the topic of Earth and the Solar System, using a 12-item, four-tier diagnostic test. The instrument was distributed via Google Form, with printed sheets provided for students without digital devices, and was developed based on the Merdeka Curriculum. The analysis is divided into two sections: Section 1 categorizes students' understanding into five types (SK, FP, FN, M, and LK), while Section 2 identifies forms of misconceptions in each subtopic. These findings are expected to help teachers identify misconceptions more accurately and adjust their teaching strategies, as well as contribute to improving the overall quality of science education.

Students' Conceptions in Earth and Solar System Topics

The data contained in Figure 2 is the overall answer to students' conceptions of Earth and solar system material that has been summarized based on categorization, namely Scientific Knowledge (SK), false positive (FP), false negative (FN), misconceptions (M), and lack of knowledge (LK).

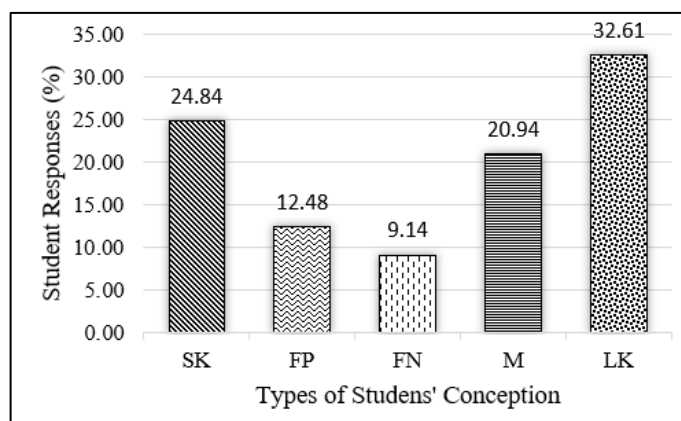


Figure 2 Percentage of student conceptions in earth and solar system

The analysis of student responses in Figure 2 showed that the most dominant category of student conceptions regarding the Earth and solar system was lack of knowledge (LK) at 32.61%. This indicates that many students were unfamiliar with or had limited exposure to the concepts, likely due to the complexity of the four-tier diagnostic test format and insufficient engagement with the material ([Karomah & Wulandari, 2023](#); [Sibela et al., 2024](#)).

Scientific Knowledge (SK) followed at 24.84%, suggesting that a significant portion of students had a scientifically accurate understanding, possibly due to effective instruction and learning environments. In contrast, misconceptions (M) were identified in 20.94% of students, reflecting the persistence of incorrect beliefs that are often difficult to change and may stem from misleading prior knowledge or inadequate explanations provided by teachers ([Andrade, 2021](#); [Efendi et al., 2023](#); [Kiray & Simsek, 2021](#)).

The analysis of student responses, presented in Figure 2, revealed that the most dominant category of student conceptions regarding the Earth and solar system was a lack of knowledge (LK), accounting for 32.61%. This suggests that many students were unfamiliar with or had limited exposure to key concepts such as the causes of day and night, planetary motion, and the Sun's apparent movement. These findings may reflect both the abstract nature of the topic and the limited time allocated to astronomy in the curriculum ([Karomah & Wulandari, 2023](#); [Sibela et al., 2024](#)). The complexity of the four-tier diagnostic test may have also contributed to student difficulty, as the instrument requires not only selecting an answer but also providing a reason and assessing confidence, which can be cognitively demanding for junior high school students.

Scientific Knowledge (SK) was observed in 24.84% of responses, indicating that some students had a solid grasp of the material. This may result from the effective use of instructional strategies or the incorporation of visual aids and models in the teaching process. However, misconceptions (M) were still present in 20.94% of students, particularly in subtopics such as the phases of the moon and Earth's revolution. These misconceptions often arise from intuitive reasoning or everyday observations that conflict with scientific explanations ([Andrade, 2021](#); [Efendi et al., 2023](#); [Kiray & Simsek, 2021](#)). The persistence of these incorrect beliefs highlights the need for more interactive and conceptually focused teaching approaches to foster deeper understanding.

False positives (FP), at 12.48%, occur when students answer correctly without truly understanding the concept, often the result of guessing or superficial knowledge. This issue is known to be challenging to minimize and may require inquiry-based or problem-based learning strategies to address ([Yew & Goh, 2016](#)). False negatives (FN), the least common at 9.14%, happen when students understand a concept but answer incorrectly, often due to misreading or carelessness.

These findings underscore the need for diverse, student-centered instructional methods to strengthen understanding and reduce learning gaps, especially regarding abstract scientific concepts (Efendi et al., 2023; Sibela et al., 2024; Yew & Goh, 2016). To better understand students' comprehension of the Earth and the solar system, student concept analysis was conducted on three subtopics: solar system, earth and satellites, and getting closer to the sun. The results of students' conceptions in each subtopic are shown in Figure 3.

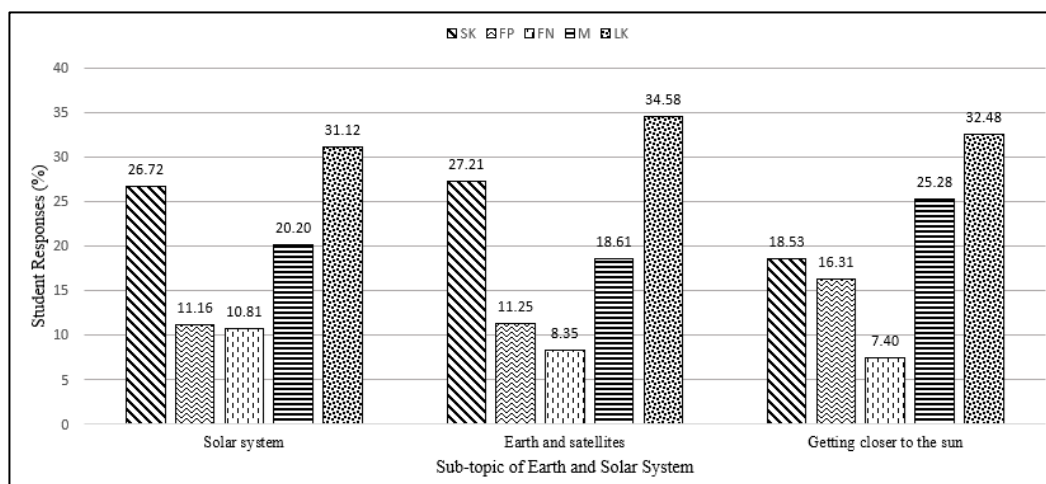


Figure 3 Percentage of student conceptions in each subtopic

Based on Figure 3, the analysis of students' understanding across three subtopics related to the Earth and Solar System shows that the *Lack of Knowledge* category holds the highest percentage in each subtopic: 31.12% for the Solar System topic, 34.58% for Earth and Satellites topic, and 32.48% for the Getting Closer to the Sun topic. This indicates that many students still do not understand the basic concepts related to these topics. One possible cause is that the solar system material is usually placed at the end of the science textbook in the *Kurikulum Merdeka*, resulting in limited time for thorough learning (Resbiantoro et al., 2022). In addition, these subtopics not only discuss planets but also include concepts such as gravity, characteristics, and the atmosphere in outer space, which require clear and engaging learning methods to help students grasp the content effectively.

The *Scientific Knowledge* category ranks second across the three subtopics, with approximately a quarter of students demonstrating correct scientific understanding: 26.72% in the Solar System subtopic and 27.21% in Earth and Satellites. This shows that some students already have a good science foundation, likely due to previous learning at earlier education levels or access to supporting resources such as children's encyclopedias (Kurniawan, 2023; Wijaya et al., 2016). However, the relatively low number of students reaching this level suggests that more inclusive and effective teaching strategies are needed to ensure that all students can fully understand the concepts.

Meanwhile, *Misconceptions* consistently rank third in all subtopics, with percentages of 20.20% in the Solar System, 18.61% in Earth and Satellites, and 25.28% in Getting Closer to the Sun. This indicates that many students hold incorrect understandings of key concepts, for example, the belief that Venus is the hottest planet because it is closest to the sun, when in fact, the real cause is the greenhouse effect and its slow rotation (Tumanggor et al., 2020). In the Earth and Satellites sub-topic, some students think the Moon is the only satellite in the solar system and do not understand the differences between Earth's rotation and revolution (Nisa et al., 2024). For the Sun subtopic, misconceptions arise due to the lack of a detailed explanation of the Sun's characteristics during the learning process.

This variation in student understanding suggests the need for targeted teaching interventions, such as the development of specific learning modules focused on frequently misunderstood concepts (Putri et al., 2024). Conceptual change approaches and the promotion of critical thinking are essential to bridging these knowledge gaps. Overall, these findings emphasize the importance of comprehensive and in-depth teaching strategies to correct misconceptions and strengthen students' scientific understanding of the Earth and Solar System (Azizah et al., 2022; Resbiantoro et al., 2022; Tumanggor et al., 2020). A more detailed explanation of the misconception is provided in Section 2.

Students' Misconceptions of Earth and Solar System Topic

Students' understanding of earth and solar system topics often leads to misconceptions that can affect how they understand astronomical phenomena. In this section, students' misconceptions on each sub-topic will be analyzed. Figure 4 shows the overall misconceptions found in each of the questions in the four-tier diagnostic test, according to three subtopics in Earth and solar system.

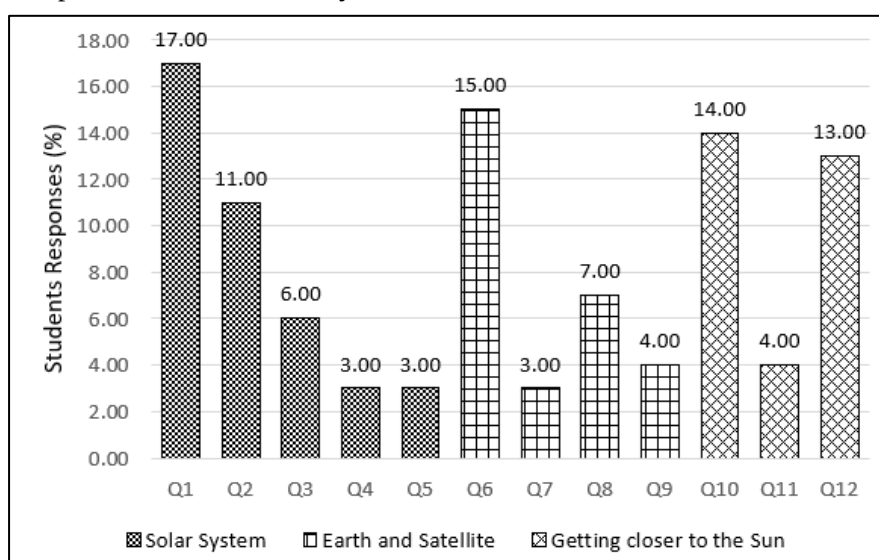


Figure 4 Percentage of students' misconceptions on earth and solar system

Based on Figure 4, the highest percentages of misconceptions were identified in question number 1 of the solar system sub-topic, question numbers 6 of the Earth and satellites sub-topic, and question number 10 of the "Getting Closer to the Sun" sub-topic. These findings indicate that misconceptions are widespread across almost all subtopics, reflecting a general lack of understanding among students regarding key concepts in Earth and solar system topics. Such misconceptions, if not addressed early, can persist and hinder students' scientific reasoning and long-term conceptual development. Therefore, early identification of misconceptions is crucial so that teachers can apply targeted interventions and corrective strategies to help students reconstruct their understanding based on accurate scientific principles (Azizah et al., 2022; Harahap et al., 2022; Putri et al., 2024).

Misconceptions in one area can also influence students' comprehension of related concepts, leading to a chain of misunderstanding that undermines deeper learning. For example, a lack of knowledge about which celestial bodies belong to the solar system can prevent students from accurately understanding their characteristics. This is reflected in the misconception identified in question number 1 (as shown in Table 5), where many students incorrectly answered why Venus is the hottest planet. This suggests a misunderstanding related to planetary characteristics, particularly the greenhouse effect in Venus's atmosphere. These findings emphasize the importance of addressing core misconceptions

to support students in developing a coherent and scientifically accurate understanding of Earth and solar system concepts ([Resbiantoro et al., 2022](#); [Tumanggor et al., 2020](#); [Wijaya et al., 2016](#)).

Table 5 Misconception result in question number 10

Subtopic	Tier	Question	Misconception Result
Solar System	1	Take a look at the following picture. 	SK Responses: BADA M Responses: 215 responses AAAA: 33.95% AABA : 14.42% AACA : 8.37% CAAA : 3.26% CABA : 1.40% CACA : 2.79% DAAA : 5.58% DABA : 3.26% DACA : 4.65%
	2	Planet Venus is the hottest planet in the solar system. Why is Venus the hottest planet? A. Planet Venus is close to the Sun B. Planet Venus has a longer rotation period than its revolution period C. Planet Venus has no water, oxygen, or gravity D. Planet Venus has more extreme temperatures, and its temperature exceeds that of the Sun	
	3	Are you sure about your answer? A. Yes B. No	
	4	What is the reason for your answer? A. The surface of Venus, which has a thick atmosphere rich in carbon dioxide, is exposed to excessive solar heat, causing evaporation. B. The surface of Venus, which has a thick atmosphere rich in carbon dioxide, is exposed to more solar C. heat because of its close distance to the Sun. D. The surface of Venus, which has a thick atmosphere rich in carbon dioxide, is exposed to solar heat, and the Sun's energy passes through the surface of Planet Venus.	
	5	Are you sure about your answer? A. Yes B. No	

Based on the results shown in Table 1, the analysis of students' responses regarding the reason why Venus is the hottest planet reveals a significant misconception, with 215 students (33.95%) incorrectly associating Venus's high temperature with its proximity to the Sun. Many students selected inaccurate justifications, such as believing that Venus's thick atmosphere causes evaporation, rather than understanding its role in trapping heat through the greenhouse effect. This misunderstanding indicates a lack of comprehension about how a planet's atmosphere influences surface temperature, particularly in the case of Venus, whose dense, carbon dioxide-rich atmosphere creates an extreme greenhouse effect ([Azizah et al., 2022](#); [Suyono et al., 2023](#)). This misconception highlights the need for science instruction that emphasizes atmospheric dynamics and corrects the mistaken belief

that distance from the Sun is the sole determinant of a planet's temperature. Instructional approaches that incorporate explanations about the greenhouse effect and atmospheric composition can help students build a more accurate scientific understanding. Another misconception is found in question 6 in the Earth and Satellite Topic and can be seen in Table 6.

Table 6 Misconception result in question number 6

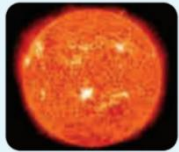
Subtopic	Tier	Question	Misconception Result
Earth and Satellite	1	What effect does the earth's revolutionary motion have on life on earth?	SK responses: BABA
		A. The occurrence of day and night	M Responses: 193 responses
		B. Determine the seasonal changes throughout the year.	AAAA: 84.97%
		C. The occurrence of the tidal cycle	AACA: 6.22%
	2	D. Regulates the direction of local winds	AADA: 2.07%
		Are you sure about your answer?	CAAA: 2.07%
		A. Yes	CACA: 0.52%
		B. No	CADA: 1.55%
	3	What is the reason for your answer?	DAAA: 1.04%
		A. This process causes changes in day and night each day.	DACA: 0.00%
		B. It causes differences in the intensity of sunlight received in different parts of the Earth.	DADA: 0.52%
		C. It is mainly influenced by the gravitational attraction of the moon and the sun.	
	4	D. It is affected by differences in atmospheric temperature.	
		Are you sure about your answer?	
		A. Yes	
		B. No	

Based on Table 6, the analysis of students' responses regarding the effects of Earth's revolution reveals a widespread and fundamental misconception. A total of 193 students (84.97%) incorrectly believed that Earth's revolution causes the occurrence of day and night, when in fact, this phenomenon results from Earth's rotation. Many students are also confused about the causes of seasonal changes and variations in sunlight intensity, attributing them incorrectly to Earth's rotation rather than its revolution. This indicates not only a lack of understanding of key concepts but also confusion in students' reasoning and terminology ([Suyono et al., 2023](#)).

This finding aligns with previous studies that show that students frequently confuse the terms and effects of rotation and revolution, often using one term to refer to the other and misunderstanding the physical processes involved. According to Duda and Adpriyadi (2020), such misconceptions, if not addressed early, can interfere with students' deeper scientific reasoning and long-term conceptual development.

To overcome these misunderstandings, it is important to apply interactive, visual, and contextualized teaching strategies that clearly differentiate between the two concepts. Using everyday examples such as the change of seasons, the length of shadows, and the alternation of day and night can help make the concepts more relatable. Strengthening conceptual understanding through continuous assessment and reflection is essential to prevent persistent errors and support more accurate scientific thinking ([Duda & Adpriyadi, 2020](#)). On the topic of Getting Closer to the Sun, the most misconceptions were found in question number 10, as shown in table 7.

Table 7 Misconception result in question number 10

Subtopic	Tier	Question	Misconception Result
Getting Closer to the Sun	1	Take a look at the picture below!  Figure 3.9 Sun The sun has several characteristics that can be observed with specialized solar telescopes from Earth, one of which is sunspots. What are sunspots? A. A shinier region on the surface of the sun. B. Tiny particles inside the Sun. C. A dark region on the Sun's cold surface. D. Pores on the Sun's surface that give off light	SK responses: CADA M Responses: 173 responses AAAA: 23.70% AABA: 6.36% AACA: 1.16% BAAA: 5.78% BABA: 9.25% BACA: 17.92% DAAA: 8.09% DABA: 14.45% DACA: 12.72%
	2	Are you sure about your answer? A. Yes B. No	
	3	What is the reason for your answer? A. The presence of stronger light around the sun. B. A greater concentration of hot gases around the sun. C. The presence of many small surfaces around the sun. D. A magnetic field from inside the Sun.	
	4	Are you sure about your answer? A. Yes B. No	

Based on Table 7, students demonstrated misconceptions in identifying one of the Sun's characteristics, specifically sunspots. While the correct answer describes sunspots as dark regions on the Sun's cooler surface caused by magnetic activity, 173 students chose incorrect options. Notably, 23.72% of students believed sunspots were shinier areas on the Sun, and 17.92% assumed they were small particles inside the Sun. These misconceptions reflect a misunderstanding of visualizing and conceptualizing sunspots. Students often associated the term "spots" with brightness or small physical elements, rather than recognizing their actual properties and effects on space weather and climate ([Basyarudin & Effendy, 2007](#); [Mardian et al., 2022](#)).

These findings suggest limited exposure and insufficient visual support during instruction. Many students were unfamiliar with sunspots, likely due to abstract teaching methods lacking concrete representations. As supported by previous research, the integration of visual-based learning tools such as diagrams, images, and simulations can significantly improve comprehension and retention of astronomical concepts ([Basyarudin & Effendy, 2007](#); [Mardian et al., 2022](#)). Enhancing instruction with engaging visuals and explanations enables students to form more accurate mental models and reduces confusion surrounding phenomena such as sunspots. Therefore, it is essential that educators incorporate visual media to help students build a clearer, more meaningful understanding of the Sun and its characteristics.

Learning is an interactive process that requires collaboration between teachers, students, and learning resources to achieve conceptual understanding. Misconceptions, incorrect yet strongly held beliefs, are common in science education and must be identified and

addressed systematically. In topics such as Earth and the solar system, these misconceptions often arise due to the abstract nature of the content and various internal or external factors. Diagnostic tools, such as interviews and two-tier tests, are effective in uncovering students' reasoning and confidence levels. Therefore, strong teacher-student interaction and appropriate diagnostic strategies are essential to support accurate scientific understanding ([Muhabib et al., 2024](#); [Xie et al., 2023](#)).

Interview with Students

- Researcher:* In the answers to questions 1, 6, and 10 above, you get misconceptions. Can you explain the reasons why you chose that answer?
- Students 1:* I choose the answer that I know; if I don't know, I just choose the answer.
- Students 2:* I answered the question using my own feelings without knowing whether the answer was right or wrong.
- Researcher:* Why do you have confidence in that answer even though it is the wrong answer?
- Students 2:* I am interested in the topic, and I have read a few books about it. So I am sure that the answer I chose is correct with the knowledge I have.
- Students 1:* Because I have learned about these topics, but not all of them were learned in school.
- Research:* What do you think about the questions? Are they difficult to answer?
- Students 1:* There are some topics that I know, so it's not too hard and not too easy.
- Students 2:* It is quite difficult to understand the questions due to the limited facilities at school, so that the delivery of material is not fully conveyed.

During interviews with students, it was revealed that misconceptions in questions 1, 6, and 10 were influenced by a combination of prior knowledge, uncertainty, and intuitive reasoning. Student 1 relied partly on familiar concepts and guessed when unsure, while Student 2 admitted to using instinct based on casual reading, without fully understanding the scientific content. Despite their misconceptions, both students showed positive learning attitudes and a willingness to improve through self-directed learning. This highlights the importance of exploring students' reasoning processes, not just their final answers. Additionally, teacher interviews were conducted to further understand students' conceptual challenges, providing qualitative insights for more effective instructional strategies ([Muhabib et al., 2024](#); [Xie et al., 2023](#)).

Interview with Teacher

- Researcher:* Previously I would like to ask for your help to review my instrument, sir. Maybe this misconception occurred because of errors or shortcomings in the instrument that I made. Is it allowed?
- Teacher:* Yes, the instrument is good enough. I believe it has been tested, but children have difficulty answering these types of questions because they are new and unfamiliar.
- Researcher:* Thank you, sir. In your opinion, are there other factors that might influence the misconceptions of these students?
- Teacher:* It can be because of their personal experience that they consider to be true, then the delivery from the previous teacher that they consider to be absolutely true.
- Researcher:* Alright sir, permission to ask questions related to learning about the solar system. What books or sources do you use, sir?
- Teacher:* I use teaching tools, videos, and school books for solar system materials.
- Researcher:* Then, in teaching science, what methods do you use to teach science?
- Teacher:* I usually involve practical-based scientific learning methods that make students actively learn, even though the activities are simple, because the characteristics of students here will prefer hands-on learning, especially with new activities.

Based on interviews with a science teacher, it was found that several interrelated factors influence students' misconceptions about the Earth and the solar system. One major issue

is students' unfamiliarity with diagnostic test formats, which can confuse even when they have learned the material ([Rohmah et al., 2023](#)). Additionally, students often carry prior experiences and misconceptions from earlier instruction, and less effective teaching practices sometimes reinforce these.

The teacher emphasized that pedagogical competence plays a key role in minimizing such misunderstandings. Furthermore, the abstract nature of astronomical content demands the use of visual aids like videos, models, and props, which help students bridge the gap between theory and perception ([Nugraha & Hidayat, 2019](#)). The teacher also noted that hands-on and inquiry-based activities increase student motivation and conceptual understanding. Overall, these findings highlight the need for better instructional design, effective teaching strategies, and engaging media to help reduce misconceptions and support deeper scientific learning.

CONCLUSION

This study concludes that junior high school students in West Bandung exhibit varying levels of understanding regarding the Earth and solar system, with a large proportion showing a lack of knowledge or specific misconceptions, particularly about planetary temperatures, the cause of day and night, and sunspots. These findings highlight the need for concept-focused instruction tailored to each subtopic. The results also suggest that instructional improvements should include visual and contextual strategies alongside teacher training programs that equip educators to recognize and address misconceptions. Strengthening curriculum design with a clearer emphasis on astronomy concepts and diagnostic assessment tools can further enhance conceptual understanding across diverse student populations.

This study reveals that junior high school students in West Bandung exhibit varied levels of understanding regarding the Earth and solar system, with many showing a lack of knowledge and deeply rooted misconceptions, especially in abstract subtopics such as the Sun and satellites. These misconceptions stem from prior experiences, inaccurate teaching, and unfamiliarity with assessment formats. However, the study is limited to a specific region and grade level, which may affect the generalizability of the results. Although the diagnostic test and interviews provided valuable insights, further longitudinal research is needed to explore the development of misconceptions over time. The findings highlight the importance of implementing contextual, visual, and practice-based science instruction, as well as equipping teachers with diagnostic tools and adaptive strategies to identify and address misconceptions early, thereby improving students' conceptual understanding in astronomy education.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

AKF: data collection, formal analysis, writing—original draft, writing—review & editing. LR: supervision, methodology, validation, writing—review & editing. NYR: validation, writing—review & editing.

REFERENCES

- Amalia, R., Sinaga, P., Sari, & Saepuzaman, D. (2016). Identifikasi miskonsepsi siswa sma di kota bandung pada konsep suhu dan kalor. *Pros. Semnas Pend. IPA Pascasarjana UM*, 1, 442–449.
- Ambarita, T. I., & Rusyati, L. (2025). Four-tier diagnostic test to assess student misconceptions about the human circulatory system. *Prisma Sains: Jurnal Pengkajian Ilmu dan Pembelajaran Matematika dan IPA IKIP Mataram*, 13(1), 1-21.

- Amelia, M., Thomas, M. M., & Rusyati, L. (2023). Analysis of students misconceptions about reproduction in plants using a four-tier diagnostic test. *Jurnal Pendidikan Matematika dan IPA*, 15(2), 287-301.
- Andrade, C. (2021). The inconvenient truth about convenience and purposive samples. *Indian Journal of Psychological Medicine*, 43(1), 86–88. <https://doi.org/10.1177/0253717620977000>
- Avinç, E., & Doğan, F. (2024). Digital literacy scale: Validity and reliability study with the rasch model. *Education and Information Technologies*. <https://doi.org/10.1007/s10639-024-12662-7>
- Azizah, S. N., Akhsan, H., Muslim, M., & Ariska, M. (2022). Analysis of college students misconceptions in astronomy using four-tier test. *Journal of Physics: Conference Series*, 2165(1). <https://doi.org/10.1088/1742-6596/2165/1/012004>
- Basyarudin, B., & Effendy, S. (2007). Keterkaitan cuaca di Indonesia dengan fenomena bintik matahari (sunspot). *Agromet*, 21(1), 1–10.
- Darmana, A., Pulungan, A. N., Nasution, H. A., Nst, M. A., & Faradilla, P. (2024). Test Instrument Validation with Rasch Model. . . In *Proceedings of the 5th International Conference on Innovation in Education, Science, and Culture*, 2023.
- Dewi, E. P., & Wulandari, F. (2021). Identification of misconceptions in science learning during the covid-19 pandemic using the cri (certainty of response index) method for primary school students. *Jurnal Penelitian Pendidikan IPA*, 7(SpecialIssue), 145–150. <https://doi.org/10.29303/jppipa.v7ispecialissue.876>
- Duda, H. J., & Adpriyadi, A. (2020). Students’ misconception in concept of biology cel. *Anatolian Journal of Education*, 5(1), 47–52. <https://doi.org/10.29333/aje.2020.515a>
- Efendi, M., Markiano, S. E., Yuniwati, I., & Adymas, P. S. (2023). The development of a two-tier diagnostic test to detect student’s misconceptions in learning process. *Mudir: Jurnal Manajemen Pendidikan*, 5(1), 92-96. <https://doi.org/10.55352/mudir>
- Gurel, D. K., Eryilmaz, A., & McDermott, L. C. (2015). A review and comparison of diagnostic instruments to identify students’ misconceptions in science. *Eurasia Journal of Mathematics, Science and Technology Education*, 11(5), 989–1008. <https://doi.org/10.12973/eurasia.2015.1369a>
- Harahap, L. K., Pratiwi, R., & Muliaman, A. (2022). Development of four-tier assessment to detect student misconceptions. *AIP Conference Proceedings*, 2645. <https://doi.org/10.1063/5.0112767>
- Kandel, B. (2020). Qualitative versus quantitative research. *Journal of product Innovation management*, 32(5), 658.
- Kaltakci-Gurel, D., Eryilmaz, A., & McDermott, L. C. (2017). Development and application of a four-tier test to assess pre-service physics teachers’ misconceptions about geometrical optics. *Research in Science and Technological Education*, 35(2), 238–260. <https://doi.org/10.1080/02635143.2017.1310094>
- Karomah, R., & Wulandari, R. (2023). Application of science explore books on earth and solar system materials to improve understanding of science concepts for grade vii students. *Academia Open*, 9(2). <https://doi.org/10.21070/acopen.9.2024.7992>
- Kiray, S. A., & Simsek, S. (2020). Determination and evaluation of the science teacher candidates’ misconceptions about density by using four-tier diagnostic test. *International Journal of Science and Mathematics Education*, 19(2021), 935–955.
- Köseoğlu, P., & Özkanbaş, M. (2023). Türkiye’s position in the global sustainable development goals: A comparison on quality education.
- Kurniawan, R. V. (2023). Analisis pemahaman konsep siswa pada topik fluida statis. *TEACHING: Jurnal Inovasi Keguruan dan Ilmu Pendidikan*, 3(1), 67-73.
- Mardian, M., Zulkarnain, M., & Adlia, S. R. (2022). Perbedaan efektivitas media audiovisual dan ceramah dalam pembekalan menghadapi kepaniteraan klinik. *Jurnal Kesehatan Masyarakat*, 6(1).

- Mellu, R. N. K., & Baok, D. T. (2020). Identifying physics teachers candidate misconception on electricity, magnetism, and solar system. *JIPF (Jurnal Ilmu Pendidikan Fisika)*, 5(3), 132. <https://doi.org/10.26737/jipf.v5i3.1694>
- Muhabib, Z., Anggoro, S., Nisa, L. C., & Amani, I. D. Z. (2024). Using a two-tier diagnostic test to analyze students' misconceptions and misunderstandings of solar system. *Forum for University Scholars in Interdisciplinary Opportunities and Networking*, 1(1), 499–507.
- Muliana, N., Pada, A. U. T., & Nurmaliah, C. (2020). Content validity of conation assessment. *Journal of Physics: Conference Series*, 1460(1). <https://doi.org/10.1088/1742-6596/1460/1/012057>
- Nasyidiah, F. I., Siahaan, P., & Sasmita, D. (2020). pengembangan instrumen four-tier diagnostic test untuk mendeteksi miskonsepsi siswa kelas x pada materi impuls. *WaPFI (Wahana Pendidikan Fisika)*, 5(2), 31-40.
- Nisa, L. C., Anggoro, S., Muhabib, Z., & Amani, I. D. Z. (2024). Analyzing students' misconceptions, incomprehension and gender differences in understanding earth's rotation-revolution concept using two-tier diagnostic test. In *Forum for University Scholars in Interdisciplinary Opportunities and Networking*, 1(1), 759-768.
- Nugraha, B. S., & Hidayat, I. (2019). Implementasi media pembelajaran interaktif “sistem tata surya” untuk kelas vi sekolah dasar. *INFOS Journal-Information System Journal*, 1(3), 1-6.
- Putri, J. H., Diva, D. F., Dalimunthe, N. F., Prasiska, M., & Irani, A. R. (2024). Miskonsepsi dalam pembelajaran matematika: Sebuah tinjauan literatur terhadap penelitian-penelitian terbaru. *JagoMIPA: Jurnal Pendidikan Matematika Dan IPA*, 4(3), 580–589. <https://doi.org/10.53299/jagomipa.v4i3.749>
- Resbiantoro, G., Setiani, R., & Dwikoranto. (2022). A review of misconception in physics: The diagnosis, causes, and remediation. *Journal of Turkish Science Education*, 19(2), 403–427. <https://doi.org/10.36681/tused.2022.128>
- Ridzuan, M. F., Lian, L. H., Fozee, F. A. A., & Nasser, S. N. A. M. (2020). Rasch analysis model: Reliability and validity of Superitem Test Instrument. *International Journal of Academic Research in Progressive Education and Development*, 9(4), 1–11.
- Rohmah, M., Priyono, S., & Sari, R. S. (2023). Analisis faktor-faktor penyebab miskonsepsi peserta didik sma. *UTILITY: Jurnal Ilmiah Pendidikan dan Ekonomi*, 7(01), 39-47.
- Saputri, I. D., & Rusyati, L. (2024). Analysis of junior high school students' misconceptions about the human excretion using a four-tier diagnostic test. *Jurnal IPA & Pembelajaran IPA*, 8(2), 123-130.
- Sevgi, S., & Karakaya, M. (2020). *Mathematics Teacher, Kayseri Kadir Has Middle School, Ministry of National Education*. www.iojpe.orgORCID:<https://orcid.org/0000-0002-6611-5543>ORCID:<https://orcid.org/0000-0002-9263-3213>
- Sibela, S., Rahman, N. A., Hamid, F., & Saprudin. (2024). Analysis of cognitive abilities of class vii students in physics learning after the application of the model advance organizer learning. *Islamic Journal of Integrated Science Education (IJISE)*, 3(2), 1–11. <https://doi.org/10.30762/ijise.v3i2.3018>
- Soeharto S., Sarimanah, E., Dewi, F. I., & Sabri, T. (2019). A review of students' common misconceptions in science and their diagnostic assessment tools. *Jurnal Pendidikan IPA Indonesia*, 8(2), 247–266.
- Suyono, S., Aini, K., & Sanjaya, I. G. M. (2023). The effectiveness of the six tier diagnostic test (stdt) instrument in viewed from empirical validity to identify student's misconceptions in chemical equilibrium materials. *IJORER: International Journal of Recent Educational Research*, 4(6), 827–836.
- Trundle, K. C., & Troland, T. H. (2005). The Moon in children's literature. *Science and Children*, 43(2), 40–43.

- Tumanggor, A. M. R., Supahar, S., Ringo, E. S., & Harliadi, M. D. (2020). Detecting students' misconception in simple harmonic motion concepts using four-tier diagnostic test instruments. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, 9(1), 21–31. <https://doi.org/10.24042/jipf.albiruni.v9i1.4571>
- Widiyatmoko, A., & Shimizu, K. (2018). The development of two-tier multiple choice test to assess students' conceptual understanding about light and optical instruments. *Jurnal Pendidikan IPA Indonesia*, 7(4), 491–501. <https://doi.org/10.15294/jpii.v7i4.16591>
- Wijaya, C. P., Supriyono Koes, H., & Muhardjito. (2016). The diagnosis of senior high school class X MIA B students misconceptions about hydrostatic pressure concept using threetier. *Jurnal Pendidikan IPA Indonesia*, 5(1), 14–21.
- Xie, Y., Huang, Y., Luo, W., Bai, Y., Qiu, Y., & Ouzang, Z. (2023). Design and effects of the teacher-student interaction model in the online learning spaces. *Journal of Computing in Higher Education*, 35(1), 69–90.
- Yew, E. H. J., & Goh, K. (2016). Problem-based learning: An overview of its process and impact on learning. *Health Professions Education*, 2(2), 75–79. <https://doi.org/10.1016/j.hpe.2016.01.004>

AUTHOR PROFILES



Annaya Keisa Fasya
annayakeisyafasya@upi.edu
 Universitas Pendidikan Indonesia



Lilil Rusyati
lilitrusyati@upi.edu
 Meta-affective, Meta-Cognitive, Assessment
 Universitas Pendidikan Indonesia
<https://scholar.google.com/citations?hl=id&user=mYnQ0DgAAAAJ>
<https://sinta.kemdikbud.go.id/authors/profile/6102491>
<https://www.scopus.com/authid/detail.uri?authorId=57190938966>



Nuryani Y. Rustaman
nuryanirustaman@upi.edu
 Thinking Process, Inquiry and Science Process Skill, Learning Theory, Biodiversity, Assessment
 Universitas Pendidikan Indonesia
<https://scholar.google.com/citations?hl=id&user=vv1LzDwAAAAJ>
<https://sinta.ristekbrin.go.id/authors/detail?id=5991811&view=overview>
<https://www.scopus.com/authid/detail.uri?authorID=5587269700>