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### Profiling Junior High School Students' Misconceptions Using a Four-Tier Test

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#### ABSTRACT

Science education covers material related to the natural world, which consists of various scientific concepts that have been agreed upon by experts. If the diversity of concepts studied by students is not managed and directed appropriately by teachers, this has the potential to cause errors in understanding the correct concepts. To measure the level of students' understanding of concepts after studying a subject, teachers need to identify that understanding. This study aims to analyze students' misconceptions about vibration, waves, and light. The research method used is descriptive with a quantitative approach. The research population consists of 9<sup>th</sup> grade students in junior high school. The sampling technique used was cluster sampling with the criteria of public schools, accredited A, and the same teacher in each school; based on these criteria, the research sample consisted of 85 students. The research data was collected through 17 items of the Four-Level Test, which consisted of four levels: multiple-choice questions, confidence in answers, reasons for answers, and confidence in reasons for answers. The average misunderstanding experienced by students based on the learning objectives in the material on vibrations, waves, and light was classified as low, namely 8%. The highest misconception was found in the learning objective of applying the concept of vibration in everyday life, which was 47%. The lowest percentage of misconception, 14%, was found in the learning objective of classifying examples of waves. The results of this study can be used as a basis for educators to design learning that emphasizes strengthening conceptual understanding and clarifying misconceptions in the material on vibrations, waves, and light.

**Keywords:** cluster sampling, four-tier test, misconception, quantitative descriptive, vibration waves and light

## Introduction

Education is viewed as a conscious process of passing on values and culture from one generation to the next (Rahman et al., 2022). Education plays a strategic role in developing individual abilities and potential, making the learning process within it key to shaping competent and competitive students. According to Law of the Republic of Indonesia Number 20 of 2003 about the National Education System, education is described as a planned, methodical process that produces learning opportunities that allow students to grow and participate actively. To assist the optimization of the function of education, the government has developed a curriculum as one of the basic components of the national education system (Rahayu et al., 2023).

The curriculum serves as the main guideline that determines the direction, objectives, material, and implementation of the educational process, thereby directly influencing the graduation standards of students in educational institutions (Anggraini et al., 2022). The curriculum can be understood as a collection of learning plans that contain planned, organized, and well-structured learning materials and content (Khoirurrijal et al., 2022). In Indonesia, science is one of the required topics for both elementary and secondary school students (Sirajudin et al., 2022).

Natural Sciences is a field of study that examines various natural phenomena and events that occur in the surrounding environment, including those related to humans. IPA material is organized in the form of subjects that are tailored to the level of education and stage of development of the students. Pedagogically, science learning is viewed as a process that tries to improve scientific thinking, communication, action, and behavior skills that are essential for human life. To support students' understanding of various concepts in science learning, teachers can relate these concepts to experiences and real situations that are relevant to students (Pertiwi et al., 2018).

In learning activities, conceptual understanding is an essential skill that students must possess to support deeper mastery of the material (Novanto et al., 2023). Conceptual comprehension is described as a person's capacity to interpret knowledge received through experience, events, or observations so that this knowledge can be applied appropriately in everyday situations (Lestari et al., 2024). Conceptual understanding of a topic or material in science learning needs to be accurate and comprehensive in order to minimize conceptual errors (Sulthon, 2017).

Misconception is a term that refers to inaccuracies in understanding a concept. This condition arises when someone believes or interprets a concept in a way that is inconsistent with scientific explanations that are recognized and accepted by experts (Mardyah et al., 2024). Misconceptions can impede students ability to learn, especially in acquiring and developing new knowledge (Utami, 2017), Therefore teachers need to identify students who show misunderstandings so that they can be given appropriate treatment. This identification procedure can be carried out through the use of test instruments intended to separate between students who understand, do not understand, or have a misconception about a concept (Paramitha et al., 2021).

Caleon & Subramaniam (2010) state that through the use of the Four-Tier Test instrument, teachers can acquire a clearer picture of the knowledge and understanding of ideas possessed by students, how they explain them, and whether they truly

understand or misunderstand the material or concepts taught. In its implementation, students can answer several questions, each of which contains four levels. The first level offers multiple-choice questions with four response alternatives. At the second level, students are asked to indicate their level of confidence in the solution they have chosen. The third level concentrates on the reasoning behind the answer option, while the fourth level asks students to declare their level of confidence in the reasons stated at the prior level.

Based on preliminary studies conducted in several schools in the 9<sup>th</sup> grade science teachers, it was found that these teachers had never used tests specifically designed to measure students' misconceptions. In science learning, there are several materials that often cause difficulties for students in understanding concepts correctly, one of which is the material on vibrations, waves, and light. Student's unfamiliarity with various foreign terms causes them to face obstacles in completing questions related to this material. Therefore, the researcher felt it necessary to explore and identify the misconceptions experienced by junior high school students.

## Methods

This study blends a descriptive method with a quantitative approach. A descriptive approach is a kind of study that concentrates on one variable on its own without comparing or developing connections with other variables (Abu Bakar, 2021). This research uses a quantitative methodology since the data collected, interpreted, and presented are all in the form of numbers that can be processed statistically (Jayusman & Shavab, 2020).

The sample strategy utilized was cluster sampling with the criterion of public schools, accredited A, and having the same teachers in each school. Based on these criteria, the research sample consisted of 85 students. Research data was collected using a four-tier test instrument, which aimed to reveal students' misconceptions by analyzing their written answers at each question level. The questions used were taken from previous researchers' questions, then developed and adapted to the learning objectives. Before use, the test sheets underwent various stages such as validity testing, reliability testing, discrimination analysis, and question difficulty level analysis. After obtaining the data, the researchers grouped the students' answers based on the Four-Tier Test categories developed by Gurel et al. (2015), as shown in Table 1 below.

**Table 1.** Four-Tier Test Category Guidelines

Tier				Category	Tier				Category
I	II	III	IV		I	II	III	IV	
True	Sure	True	Sure	SC	False	Sure	True	Sure	FN
True	Sure	True	Not Sure	LK	False	Sure	True	Not Sure	LK
True	Not Sure	True	Sure	LK	False	Not Sure	True	Sure	LK
True	Not Sure	True	Not Sure	LK	False	Not Sure	True	Not Sure	LK
True	Sure	False	Sure	FP	False	Sure	False	Sure	MSC
True	Sure	False	Not Sure	LK	False	Sure	False	Not Sure	LK
True	Not Sure	False	Sure	LK	False	Not Sure	False	Sure	LK
True	Not Sure	False	Not Sure	LK	False	Not Sure	False	Not Sure	LK

Source: Gurel et al. (2015)

Description:

SC	:	Scientific Conception	FN	:	False Negative
LK	:	Lack of Knowledge	MSC	:	Misconception
FP	:	False Positive			

Following the categorization of the students' responses, the following calculation formula is used to identify the category of the students' conceptual comprehension for each question item:

$$P = \frac{s}{j} \times 100$$

Where P = percentage of students in each category (understand the concept, misconception, do not understand the concept), s = many students in each category (understand the concept, have misconceptions, do not understand the concept), j = number of students participating in the study.

The determination of low, moderate, and high levels of misconception can be based on Table 2.

**Table 2.** Levels of Misconception

Percentage Range	Level
0% - 30%	Low
31% - 60%	Medium
61% - 100%	High

Source: Maison et al. (2021)

## Results and Discussion

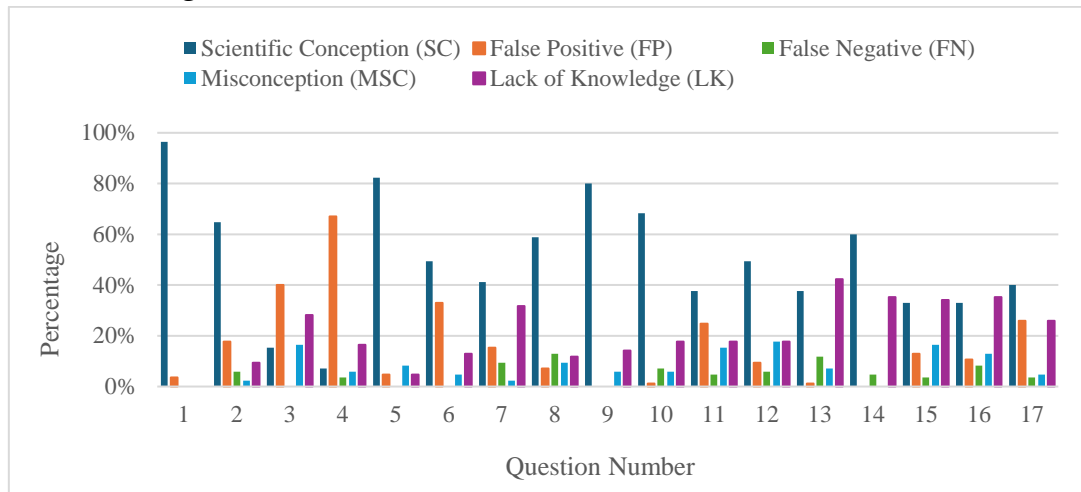
The data provided by the Four-Tier Test was used to categorize students into three categories of comprehension, scientific conception (SC), false positive (FP), false negative (FN), misconception (MSC), and Lack of Knowledge (LK). The grouping results are provided in table 3 below.

**Table 3.** Concept Understanding Profile for Each Question Item

Question Number	Scientific Conception (SC)	False Positive (FP)	False Negative (FN)	Misconception (MSC)	Lack of Knowledge (LK)	Sample Size
1	82	3	0	0	0	85
2	55	15	5	2	8	85
3	13	34	0	14	24	85
4	6	57	3	5	14	85
5	70	4	0	7	4	85
6	42	28	0	4	11	85
7	35	13	8	2	27	85
8	50	6	11	8	10	85
9	68	0	0	5	12	85
10	58	1	6	5	15	85
11	32	21	4	13	15	85
12	42	8	5	15	15	85
13	32	1	10	6	36	85
14	51	0	4	0	30	85
15	28	11	3	14	29	85
16	28	9	7	11	30	85
17	34	22	3	4	22	85

The results in Table 3 show that question number 12 had the highest number of students with misunderstandings, namely 15 students. Meanwhile, the highest level of concept understanding was obtained in question number 1, with 82 students

answering correctly. The percentage of concept comprehension for each question item can be seen in the Figure 1.



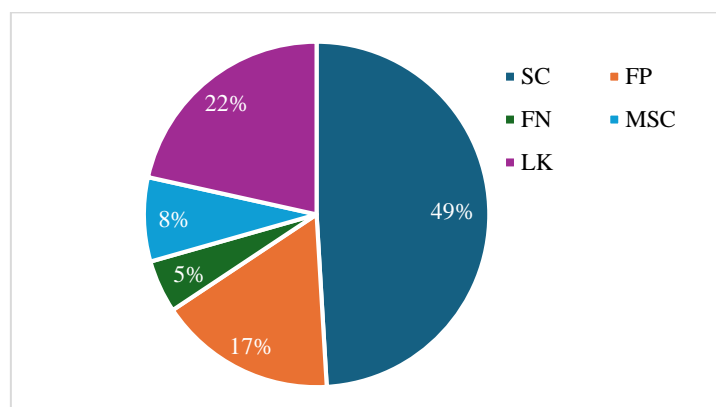
**Figure 1.** Percentage of Concept Understanding for Each Question Item

The average misunderstanding experienced by students for each learning objective can be seen in Table 4.

**Table 4.** Average Percentage of Concept Understanding for Each Learning Objective

Learning Objectives	SC	FP	FN	MSC	LK	Question Number
1. Implementing the concept of vibration in everyday life	69%	8%	2%	9%	11%	1, 5, 9, 11, 12
2. Conclude that waves are propagating vibrations	41%	24%	6%	8%	21%	3, 6, 7, 8
3. Classifying examples of waves	50%	21%	5%	4%	20%	2, 4, 10, 14
4. Using the concept of light waves to explain everyday events	35%	36%	13%	10%	37%	13, 15, 16, 17
Average Total	49%	17%	5%	8%	22%	

The percentage of concept comprehension for each question item can be seen in the Figure 2.



**Figure 2.** Average Percentage of Concept Understanding Based on Learning Objectives

The results in Table 4 show that students had the highest misconception of 10% in the learning objective of using the concept of light waves to explain everyday events.

Conversely, the lowest misconception, which was 4%, was found in the learning objective of Classifying examples of waves. Details of the student's misperception profiles for each learning aim may be found in Table 5.

**Table 5.** Misconception Among Students for Each Learning Objective

Learning Objective	Percentage of Misconception	Level
1. Implementing the concept of vibration in everyday life	47%	Medium
2. Conclude that waves are propagating vibrations	33%	Medium
3. Classifying examples of waves	14%	Low
4. Using the concept of light wave propagation to explain everyday events	41%	Medium

Based on Table 5, students had the most misconceptions about the learning objective of implementing the concept of vibration in everyday life (47%) with a medium category, and the fewest misconceptions about the learning objective of Classifying examples of waves (14%).

Based on the research results obtained, explanations related to the answer choices of students identified as having misconceptions in each learning objective are described below.

#### **A. Implementing the concept of vibration in everyday life**

The learning objectives that implement the concept of vibration in everyday life are measured through five questions, namely numbers 1, 5, 9, 11, and 12. In question number 1, students assume that one vibration occurs when the pendulum passes through one equilibrium point, without returning to the original point of the pendulum. This understanding is incorrect. The period is defined as the time interval required for an object to complete one full vibration (Yanti et al., 2020), which is when the pendulum moves from the starting point (A), passes through the equilibrium point (B), to the furthest point (C), passes through point B again, and finally returns to its original point (A).

Question number 5, students assume that if a pendulum moves from point A to point B to point C, it has undergone two cycles of oscillation. The correct concept is that if a pendulum moves from point A to point B to point C, it has only undergone half a cycle of oscillation.

Question number 9, students assume that one vibration occurs when a pendulum moves straight forward. This is not entirely correct. The correct concept is that one vibration occurs when the pendulum moves back and forth regularly through the equilibrium point (Christiani et al., 2021).

In question number 11, some students understood that a longer pendulum string causes an increase in frequency and period. However, the formula  $T = 1/f$  states that frequency and period are inversely proportional, meaning that the

longer the pendulum string, the greater the period of oscillation and the smaller the frequency.

In question number 12, students misunderstood the concept of frequency, thinking it was the length of time for one full vibration. The correct concept states that frequency is the number of vibrations performed by an object in one second (Yanti et al., 2020).

### ***B. Conclude that waves are propagating vibrations***

The learning objective concludes that waves are vibrations that propagate, as measured through four questions, namely numbers 3, 6, 7, and 8. In question number 3, students assume that waves are the flow of particles from one place to another because waves arise from the flow of propagating particles. However, the correct concept is that waves are vibrations that propagate energy without moving the medium (Rosyidah et al., 2023).

In question number 6, students assume that frequency is the number of vibrations that occur until an object stops vibrating. This concept is incorrect, because frequency is a quantity that expresses the number of vibrations that occur during a unit of time, namely one second.

In question number 7, students assume that the higher the frequency, the longer the wavelength. This understanding is incorrect, because conceptually, wavelength is the distance traveled by one complete wave.

In question number 8, students assumed that waves can move matter, so that particles in the medium move in all directions from the source of the wave. This understanding is incorrect, because scientifically waves only transfer energy without causing the medium to move (Syahputri & Sari, 2025).

In question number 10, students assumed that electromagnetic waves require a medium to propagate. This understanding is incorrect, because conceptually electromagnetic waves can propagate without requiring a medium (Jumingin et al., 2022).

### ***C. Classifying examples of waves***

Four questions (numbers 2, 4, 10, and 14) are used to test the learning aim of categorizing wave samples. In the second question, students believe that the medium's particles travel parallel to the direction of propagation, which is a feature of transverse waves. The right idea, however, is that one of the traits of transverse waves is that the medium's particles travel perpendicular to the direction of propagation.

In question number 4, students assumed that wavelength is the distance between similar wave rolls. This concept is incorrect because wavelength starts from the center of one compression to the center of the next compression (Hidayah & Hasanah, 2025).

In question number 10, students assumed that electromagnetic waves require a medium to propagate. This understanding is incorrect, because conceptually electromagnetic waves can propagate without requiring a medium (Jumingin et al., 2022).

Students think that longitudinal waves are those whose vibration direction is perpendicular to the direction of propagation in question number 14. This idea is inaccurate, because longitudinal waves have a vibration direction that is parallel to the path of propagation.

#### ***D. Using the concept of light wave propagation to explain everyday events***

The learning objective of using the concept of light wave propagation to explain everyday events is measured through three questions, namely numbers 13, 15, 16, and 17. In question number 13, students assume that the natural phenomenon of rainbows occurs because light has different color absorption, as light absorbs certain colors so that other colors that are not absorbed appear as rainbows. This concept is incorrect because rainbows are a natural phenomenon that occurs because each light has a different refractive index so that when light is refracted into a medium, it will emit various colors like a rainbow. This refraction is the phenomenon that underlies the formation of rainbows (Zahro & Rakhmawati, 2024). Then, light is dispersed into various colors due to the difference in the refractive index of each light.

In question number 15, students assume that a swimming pool appears shallower than it actually is due to perfect reflection caused by reflection from a surface scattered from many angles. This concept is incorrect. The phenomenon of the swimming pool appearing shallower is caused by light refraction, which is the event when the direction of light propagation changes due to differences in density between the two media it passes through (Zahro & Rakhmawati, 2024).

In question number 16, it was found that students had a misconception that convex mirrors produce real, upright, and enlarged images. This is because students see the image behind the mirror as larger than the actual size of the object. This concept is incorrect, because the nature of the image produced by a convex mirror is virtual, upright, and reduced, so that the image behind the convex mirror is smaller than the size of the object (Iskandar & Marwoto, 2020).

The learning objective of identifying the parts of a telescope and camera is simply measured through one question, namely number 17. Students assume that a telescope can see objects that are very far away because the lens can extend to objects that are very far away, as the human eye can see far away with the help of glass. This concept is inaccurate. Binoculars work by using two main lenses, namely the objective lens, which captures light from distant objects to form a real image, and the eyepiece lens, which then enlarges and focuses the image so that it can be observed clearly (Adji et al., 2021).

In general, the results of the study show that students still have misconceptions about vibrations, waves, and light. In the material on vibrations, students tend to misconception the concept of a full vibration and the relationship between period and

frequency. In the material on waves, misconceptions arise in understanding waves as propagating vibrations and in and in distinguishing the characteristics of wave examples. Meanwhile, in the material on light, misconceptions are seen in students' understanding of explaining the properties of light and its application in everyday life. These findings are in line with previous research results which state that the concepts of vibration, waves, and light are abstract materials that have the potential to cause misconceptions among students (Haerunnisa et al., 2022; Irianti, 2021).

## Conclusion

Based on the results of the study, it can be concluded that students still have misconceptions about vibration, waves, and light. Identification using the Four-Tier Test instrument shows that the average level of misconception among students is in the low category, at 8%. However, the highest misconception was found in the learning objective related to the application of the concept of vibration in everyday life at 47%, while the lowest misconception was found in the learning objective of classifying examples of waves at 14%. These findings indicate that abstract physics concepts that require deep conceptual understanding are still the main source of misconceptions among students. Therefore, the results of this study can be used as a basis for educators to design learning that emphasizes strengthening conceptual understanding and clarifying misconceptions in the material on vibrations, waves, and light.

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