Exploring Middle school students' Performance of Introduction to Vibrations and Waves

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Abstract. Vibrations and waves are essential topics in science subjects at junior high school. Understanding the basic concepts of vibration and waves is crucial to understanding natural phenomena. This study aims to explore junior high school student's performance in understanding the concepts of vibration and waves and identify factors that contribute to students' concept understanding. The research method uses quantitative methods to collect and analyze data. Quantitative methods are used to obtain numerical and objective data, thus allowing researchers to measure and identify the level of understanding of student concepts more measurably. The analysis results, in general, have indicated that student performance in understanding introduction to vibrations and waves is in the low category. Most students have difficulty understanding this material, which is reflected in their low performance in understanding the concepts of vibrations, waves, sound waves, and applications in everyday life. Based on the research findings, efforts are needed to improve students' performance in understanding the concepts of vibration and waves. The recommendation is to use a more interactive learning approach that can stimulate students' problem-solving imagination.

Keywords: performance, natural science, junior high school, education, problem-solving.

1 Introduction

Understanding the concept of vibration and waves is one of the crucial aspects of science subjects [1]–[3] at the junior high school level. This concept is essential for understanding natural phenomena [4], [5] such as sound, light, and earthquakes. For this reason, exploring the concept of understanding the performance of junior high school students on vibrations and waves is very relevant and significant to improve the quality of the physics learning process.

Learning about vibrations and waves at the junior high school level is a relevant and essential foundation for understanding more complex physics concepts at higher

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education levels [3], [5]–[8]. However, the difficulty level of the material and the complexity of the concept can be a challenge for students to understand the concept.

Previous research related to the exploration of junior high school students' concept understanding on the topic of vibrations and waves has been conducted by several previous researchers to understand students' level of understanding of the material. Previous research was conducted by [9] at the university level in China. The results of the study [9] found that most students were only able to achieve intermediate level knowledge and did not have a deep conceptual understanding of wave propagation. In addition, research was conducted by [1] on 239 students at the secondary school level in Uganda. The study's results [1] found that using the problem-based learning model was more effective in improving students' understanding of propagation, reflection, and standing waves than using the usual or traditional teaching model.

Exploratory research on junior high school students' concept understanding performance on the topic of vibrations and waves conducted in this study has several differences with previous studies, such as: (1) this study uses a test set in the form of reasoned multiple choice, where this use allows the exploration results to be more comprehensive and in-depth. (2) this research was conducted in the regional context of East Lampung Regency, Lampung Province, Indonesia. This difference in context may affect the research results and the appropriateness of the findings to a particular situation. Therefore, the exploratory research of junior high school students' concept of understanding performance on vibration and waves in this study can provide unique contributions and relevant information for the world of education. The findings from this study can provide new insights, add to our understanding of the challenges and opportunities in physics learning, and guide the development of more effective and efficient learning strategies to improve students' understanding of the topic of vibrations and waves.

The study aimed to investigate and explore the concept mastery performance of junior high school students on vibration and waves. In this study, we will analyze various aspects, including students' understanding of the basic concepts of vibration and waves, their proper use of physics terms, and their ability to apply them in real-world situations. This performance analysis is expected to identify areas of difficulty for students and factors that influence their understanding of this topic. In addition, this article will also provide recommendations and effective learning strategies to improve students' concept understanding on the topic of vibration and waves.

2 Method

This study used a cross-sectional research design. This design allows researchers to collect data at one specific point in time from a representative sample of students on vibrations and waves [10]. This quantitative research method provides data that can be objectively measured and produces relevant [11] and reliable information about the performance of junior high school students' concept understanding on the topic of vibrations and waves. Accordingly, researchers can significantly contribute to a deeper understanding of the material and develop more effective learning strategies in improving student understanding of vibration and wave topics.

The population of this study was all junior high school students studying vibration and wave material in East Lampung district, Lampung Province. The total population of junior high school students in this research area was 500 students. A sample of 146 students was selected randomly to represent the variation of student characteristics in the population.

The measurement tool used in this study was a questionnaire in the form of a concept understanding test. This questionnaire was designed based on the essential vibration and wave materials competencies determined in the school curriculum. The knowledge test consists of open-ended multiple-choice questions. The selection of the open-ended multiple-choice test form is to allow students to explain the answers in more depth.

Data on the performance of students' responses were acquired using test methodologies, and the scores were split into four categories on a four-category polytomous scale. The number of categories chosen is determined by the guiding guidelines employed, from which one of the provisions of each category can be selected, as represents in **Error! Reference source not found.**.

Table 1. The Performance of Students' Responses on The Politomus Scale

Category	Description
Category 1	Students in this category choose the wrong answer and tend to give irrational reasons.
Category 2	Students in this category answer items correctly and tend to give irrational reasons.
Category 3	Students in this category choose the wrong answer and provide logical reasons based on scientific evidence.
Category 4	Students in this category answer items correctly and provide logical reasons based on scientific evidence.

Exploration of junior high school students' concept understanding of vibration and waves, the concepts tested include several main aspects, namely the concepts of vibration, waves, sound waves, and applications of vibration and waves in everyday life. The testing of these concepts is presented in matrix form in **Error! Reference source not found.**. Testing on vibration and waves aims to get a more comprehensive picture of junior high school students' concept understanding of vibration and waves.

Table 2. Matrix of Performance Test of Introduction to Vibrations and Waves

Concept	Aspect	Indicator	Items
Vibration	Analyze	Distinguish the concepts of frequency and period of vibration	1
	Analyze	Organize the easiest strategy in determining the period of vibration	2
	Evaluate	Assess the characteristics of the vibration	3
Wave	Analyze	Analyze the quantities of the waves	7
	Evaluate	Assess the correct statements about amplitude, wavelength, and frequency	4
	Evaluate	Assess the correct statements about amplitude, wavelength, and frequency	8;9
	Create	Design a graph of the results of wave observations	5;6
Sound	Analyze	Analyze the characteristics of sound waves	10;13
	Create	Propose a hypothesis based on the concept of sound waves	14;12
	Create	Design a graph of the results of sound wave observations	15
Application	Analyze	Distinguishing the concept of fast propagation in various mediums	16
	Evaluate	Assess wave concept in life	11
	Evaluate	Examine the processes that occur in hearing	18
	Create	Provides a point of view of the concept of waves in life	17

Data analysis of junior high school students' concept of understanding performance on vibrations and waves with a qualitative approach involves collecting descriptive and in-depth data about students' perceptions of the material. The results of the data analysis were interpreted in depth to understand the level of concept understanding of junior high school students on the topic of vibrations and waves using the equation presented in **Error! Reference source not found.**.

Table 3. The scale of Performance of Students'

Equation	Example Range for 2 item	Category
$\theta > M_i + 1,8 \times SD_i$	$\theta > 6,8$	Higher
$M_i + 0,6 \times SD_i < \theta \leq M_i + 1,8 \times SD_i$	$5,6 < \theta \leq 6,8$	High
$M_i - 0,6 \times SD_i < \theta \leq M_i + 0,6 \times SD_i$	$4,4 < \theta \leq 5,6$	Medium
$M_i - 1,8 \times SD_i < \theta \leq M_i - 0,6 \times SD_i$	$3,2 < \theta \leq 4,4$	Low
$\theta < M_i - 1,8 \times SD_i$	$\theta < 3,2$	Lower

The measurement tool used in the exploration of junior high school students' concept of understanding performance on the topic of vibrations and waves has been validated by experts [12]. The validation test was conducted to ensure that the measurement tool is valid and can accurately measure the level of understanding of students' concepts related to vibration and wave material. The validation test stage begins by collecting measurement tools designed by researchers based on the curriculum's essential competencies and learning indicators on vibration and wave materials. This measurement tool is then arranged in the form of questions covering various aspects of vibration and waves.

The reliability test was conducted to ensure that the measurement tool used can produce consistent and reliable results in measuring students' level of concept understanding. The reliability of the test device was evaluated using the Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST) program, which is one of the commonly used methods for calculating test reliability [13], [14].

The measurement tool used in the research to explore the performance of junior high school students' conceptual understanding of vibrations and waves has gone through a reliability test using the Quest program. The reliability result of 0.87 shows that the measurement tool has a high level of consistency in measuring students' concept understanding of vibrations and waves. As a guide, test reliability is considered good and acceptable if the value is above 0.70 [13], [14]. Therefore, the reliability result of 0.87 indicates that this test device has a more than adequate level of reliability and can be relied upon in measuring students' concept understanding on the topic of vibrations and waves.

3 Results and Discussion

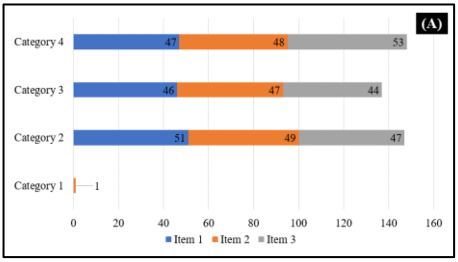
The results of student understanding performance of introduction to vibrations and waves are presented in **Error! Reference source not found.**.

Table 4. Results of Performance Analysis of Students' Understanding of Introduction to Vibration and Waves

Topic	Aspect	θ	Category
Vibration	Analyze	2,979	Lower
	Evaluate	3,034	High
Wave	Analyze	3,144	High
	Evaluate	2,886	Lower
	Create	2,986	Lower
Sound	Analyze	2,908	Lower
	Create	2,908	Lower
Application	Analyze	2,500	Medium
	Evaluate	3,021	Lower
	Create	2,925	High

The results generally show that student performance in understanding introduction to vibrations and waves is in the low category. This finding is consistent with [1], [15] findings that the ability of junior high school students to understand and master science material, especially on the topic of vibrations and waves, which is still in the low category is an issue that needs serious attention.

Three items were used to assess students' grasp of vibration. Figure 1A represents the results of the examination of students' understanding performance, and Figure 1B represents an example of one of the items, the concept of vibration. Students in this category choose the wrong answer and provide logical reasons based on scientific evidence. This category shows that most students' have understood the basic concepts of vibration, but some weaknesses or misunderstandings still need to be corrected.



(B)

Andi and Yoga observe a basic pendulum with varied lengths of string. The following are the findings from their observations.

String Length (m)	Number of vibrations	Time (s)	Time Period (s)	Frequency (Hz)
0,3	10	11	1,10	0,90
0,7	10	17	1,70	0,58
0,9	10	20	2,00	0,50
1,2	10	23	2,30	0,44
1,5	10	26	2,60	0,38

Based on Andi and Yoga's observations, a correlation between periods with the best appropriate frequency is…

A. The period of the pendulum vibration is decreasing while the frequency of the vibration is increasing.
B. The period of the pendulum is increasing while the frequency of the pendulum remains constant.
C. The period of the pendulum is increasing while the frequency of the pendulum is decreasing.
D. The period of the pendulum is increasing, while the frequency of the pendulum is increasing.

Reason: ……………………………………………………………………………………

Fig. 1. Performance of Student Understanding Concept Vibration of (A) Percentage of Scores for Each Category on the Concept Vibration, and (B) Example item Number 1 in Concept Vibration.

An example of a question item used to measure students' understanding performance on the concept of vibration is presented in Figure 1B. Item number 1 asks students' to observe the table of experimental results and then analyze the results found. The basic concept used to answer this item uses the equation for the relationship between period and vibration frequency, which is presented in equation (1).

$$T = \frac{1}{f} \tag{1}$$

The interpretation of equation (1) is that the period is inversely proportional to the vibration frequency. Thus, when the vibration period increases, the vibration frequency will decrease. Likewise, if the vibration period decreases, the vibration frequency will increase or get bigger.

Students' in Category 3 have generally been able to master the basic concepts of vibration. They can explain what vibration is, how vibration occurs, and the factors that affect vibration. However, students' have difficulty understanding more complex vibration concepts or applying more complex mathematical equations related to vibration based on observations. An example of students' understanding of performance on the topic of vibration is presented in Figure 2.

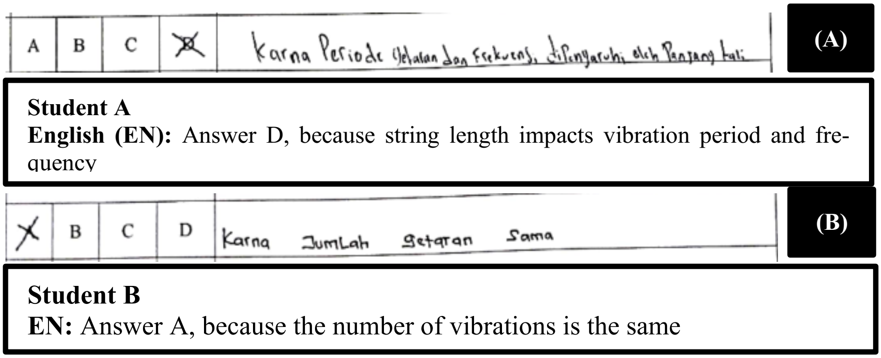


Fig. 2. Example of Student Answers to Concept Vibration

Student A's understanding performance (Figure 2A) of the vibration concept, where this learner has understood the concepts of amplitude, frequency, and period of vibration. However, they were unable to choose the correct answer. While student B (Figure 2B), this learner cannot give reasons correctly and tends to give a simple answer.

The findings of students' comprehension performance on the topic of vibration show that students' face difficulties in understanding the topic of vibration. Lack of practice in thinking abstractly and visualizing vibration and wave concepts in different scenarios can limit students' ability to create creative applications. This finding is consistent with [16], [17] findings that some students' have difficulty understanding concepts related to vibration, be it mechanical vibration, harmonic vibration, or vibration in sound waves.

However, students' may have difficulty understanding the concept of complex vibrations or applying more complex mathematical equations related to vibrations, such as reading the observation table and then relating it to mathematical equations. This result is consistent with [18], [19] The results mentioned some aspects of vibrations, such as simple harmonic vibrations, involve mathematical concepts, so that students' who lack confidence in mathematics or have not understood these mathematical concepts may experience difficulties in understanding mathematical relationships with vibration phenomena.

Students' low performance in understanding this concept may affect their understanding of physical science as a whole and the potential to pursue future fields of science and technology. This result is consistent with [9], [20], [21] the results mentioned that low-performing students may not fully understand the basic concepts of vibration and waves, such as vibration, transverse and longitudinal waves, frequency, period, and amplitude. This lack of understanding of basic concepts can hinder understanding further topics related to vibrations and waves [2], [3], [6], [7].

The taxonomy used in the exploration of Students' Performance of Introduction to Vibrations and Waves is Bloom's revised taxonomy. Bloom's taxonomy is a framework used in education to describe students' level of thinking and cognition [22]. This taxonomy has six levels: remembering, understanding, applying, analyzing, evaluating, and creating [22]. The revised Bloom's Taxonomy used in this study is specifically on analyzing, evaluating, and creating.

The student's performance results on analyzing the topic of vibrations and waves are still in the low category. This finding is consistent with [23] findings that some students do not understand the basic concepts of vibrations and waves well. A study [7] highlighted that some junior high school students struggle to analyze the properties of waves, frequency, amplitude, and period. Students' lack of understanding of vibration and wave topics may hinder their ability to analyze wave phenomena more complexly.

The results of the student's performance evaluating the topic of vibrations and waves are still in the low category. The low level of evaluation indicates that students have difficulty applying their knowledge and understanding to analyze and assess situations involving vibrations and waves. This finding is consistent with the [24] findings that some students are poorly trained in using critical thinking skills to evaluate vibration and wave phenomena. Evaluation often involves the ability to analyze and connect information from multiple sources, as well as assessing the correctness and relevance of applied physics concepts.

The results of students' performance in creating on the topic of vibrations and waves are still in the low category. This finding is consistent with [25] findings that students often lack training in using creative thinking skills to create new solutions or identify applications of vibration and wave concepts in unusual contexts. Creating in the physics context requires thinking out of the box and considering innovative approaches. A study [16] found that some junior high school students struggle to create new understandings or apply vibration and wave concepts to generate creative solutions to complex situations.

4 Conclusion

The analysis results generally show that student performance in understanding introduction to vibrations and waves is in the low category. Most students have difficulties such as: (1) distinguishing the concepts of frequency and period of vibration; (2) assessing the correct statements about amplitude, wavelength, and frequency; (3) assessing the correct statements about amplitude, wavelength, and frequency; (4) analyze the characteristics of sound waves; (5) propose a hypothesis based on the concept of sound waves; (6) design a graph of the results of sound wave observations; (7) assess wave concepts in life; and (7) examine the processes that occur in hearing.

Based on the research findings, efforts are needed to improve student performance in understanding the concepts of vibration and waves. The recommendation is to use a more interactive learning approach that can stimulate students' problem-solving imagination. Educators can stimulate the imagination through the use of visual media and experiments, as well as providing opportunities for students to discuss and ask questions. In addition, the role of the teacher in guiding and encouraging student participation in learning is also very important.

The results of this study can provide valuable insights into developing more effective and relevant learning strategies to improve students' understanding of vibration and wave materials. In addition, this study can also contribute to improving our understanding of the overall level of concept understanding of junior high school students on the topic of vibrations and waves in the physics curriculum.

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