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Deep Learning Approach and Mechanics KIT on the Shift in Conceptions of Junior High School Students on the Material of Vibrations and Waves

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Abstract: Misconceptions in vibration and wave topics remain a common problem in junior high school science learning, particularly due to the abstract nature of the concepts and their limited direct observability. This study aimed to analyze students' conceptual shifts on vibration and wave concepts through the implementation of a Deep Learning approach supported by a Mechanical KIT. The study employed a one-group pretest–posttest experimental design involving three classes, comprising one experimental class and two replication classes, with a total of 69 eighth-grade students serving as research participants. A three-tier diagnostic test consisting of ten multiple-choice items was used to identify students' conceptual categories, including guessing, lack of conceptual understanding, misconception, and sound conceptual understanding. The data were analyzed descriptively using SPSS to examine the direction and quality of students' conceptual shifts before and after the intervention. The results indicated that the Deep Learning approach, assisted by the Mechanical KIT, effectively facilitated positive conceptual shifts, as evidenced by a dominant transition from misconceptions, a lack of understanding, and guessing toward sound conceptual understanding across all classes. The most substantial conceptual improvements were observed in indicators related to the relationships among frequency, period, and amplitude, while relatively lower shifts occurred in concepts requiring higher levels of mathematical reasoning. These findings suggest that integrating a Deep Learning approach with concrete instructional media, such as a Mechanical KIT, is effective in promoting meaningful conceptual reconstruction and reducing misconceptions in vibration and wave learning.

Keywords: Conceptual Change; Deep Learning; Mechanics KIT; Vibrations and Waves.

Introduction

Science learning at the junior high school level reveals that misconceptions about fundamental concepts, such as vibration and waves, persist as a significant problem. Many eighth-grade junior high school students experience misconceptions about vibration and waves, as revealed by a three-tier diagnostic test [1].

The same thing was also reported in a study, which showed that the percentage of misconceptions of students in Serang Regency regarding the concept of vibrations and waves was in the medium to high category [2]. This misconception becomes an obstacle in students' scientific understanding, because students who have a wrong understanding often show difficulty in applying concepts conceptually and often rely on memory or guesswork [3] .

Learning that focuses solely on memorization tends to fail to address misconceptions because students are not given the opportunity to reflect on their prior knowledge or reconstruct their understanding in depth [4] . This is in line with research showing that active learning approaches that allow students to explore, discuss, and remap their knowledge have proven to be more effective in facilitating conceptual change than traditional methods [5].

Abstract physics materials, such as waves and vibrations, require experimental observation, visualization, and manipulation of concepts so that students can build a solid understanding. A survey of instrument development in mechanical waves material shows that many students have difficulty in understanding the characteristics of wave propagation and wave superposition because their initial understanding is fragmented [6].

The material on vibrations and waves has an abstract character where many aspects are not directly visible to students, such as transverse and longitudinal waves, the relationship between frequency and period, and the shape and propagation of waves [7]. Due to its abstract nature, students tend to have difficulty in distinguishing one concept indicator from another, and this strengthens the emergence of misconceptions [8].

Students' conceptual understanding of science material is an important aspect in the learning process because it determines the extent to which students are able to relate scientific concepts to real phenomena [9] . However, the material on vibrations and waves is abstract, so that students often have difficulty understanding aspects that are not directly visible, such as the difference between transverse and longitudinal waves, the relationship between frequency and period, and how waves propagate through a medium [10]. Empirical studies show that the invisibility of this concept triggers various misconceptions that persist despite conventional teaching [11].

To overcome this lack of in-depth understanding, a learning approach is needed that not only conveys material

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passively but also encourages students to think actively and reflectively [12].

Deep Learning approach in the educational context refers to a learning process that emphasizes in-depth understanding, analysis, and the connection of new concepts to prior knowledge. Although there has not been much research that specifically incorporates Deep Learning in vibration & wave material in junior high school, the concept fits the need to reduce misconceptions [13].

One of the innovative strategies in science learning is the application of deep learning (Deep Learning), which not only emphasizes the achievement of basic competencies, but also higher-order thinking skills such as analysis, synthesis, and reflection [14] . A systematic review reveals that in education, Deep Learning aims to foster deep understanding, application in new contexts, and connections between concepts and elements. which is needed to reduce misconceptions [15].

The use of physics teaching aids or Mechanics KITs provides concrete representations for phenomena that are difficult to observe directly, allowing students to test and visualize concepts such as transverse and longitudinal waves and the frequency-period relationship [14] . For example, a Mechanics KIT for vibration experiments is designed to provide direct experience with the phenomena of resonance and vibration propagation. Thus, the integration of concrete media and immersive learning approaches is predicted to increase the effectiveness of students' science learning [13].

Along with the development of contemporary learning models, recent research confirms that the application of deep learning approaches in the context of science not only increases student engagement but also strengthens higher-order thinking skills and facilitates conceptual change [17] . For example, in research by Deep Learning in Physics Education: Exploring the Potential of Mindful, Meaningful, and Joyful for a Better Learning Experience, it was found that the integration of deep learning approaches with mindful, meaningful, and joyful learning paradigms was able to significantly improve students' understanding of physics and encourage students to more actively explore and reflect on scientific concepts independently [18].

This is a strong basis that learning strategies that combine active exploration activities, reflection and inter-concept relationships make a real contribution to shifting students' initial erroneous conceptions into scientific and meaningful understanding [19].

Diagnostic tests play a crucial role in identifying student misconceptions and monitoring changes in conceptual understanding before and after learning, particularly in abstract science concepts such as vibrations and waves [20]. Related studies show that the use of diagnostic instruments such as three-tier tests is effective in identifying the level of student misconceptions so that learning interventions can be designed more appropriately [21].

In addition to the approach, the use of visual aids or aids has also proven useful in concretizing abstract concepts. For example, research on the development of visual aids or aids for physics in complex material shows that these media help students in visualizing concepts and reducing misconceptions [14].

However, there has been little research that simultaneously combines the Deep Learning approach with special teaching aids, such as the Mechanics KIT on vibration and wave material in eighth-grade junior high school, to empirically and measurably observe changes in students' conceptions.

Based on these conditions, this study is important to conduct because it aims to determine the effect of changes in the conceptions of eighth-grade junior high school students on the material of vibrations and waves through the application of the Deep Learning approach and KIT Mechanics, as stated in the abstract. Instruments such as three-tier diagnostic tests will be used, so that changes in conception are not only based on scores, but also on the categories of conception (guessing, misconceptions, not understanding the concept, and understanding the concept). With a one-group pretest-posttest experimental research design in each class, this study is expected to provide empirical evidence regarding the effectiveness of combining learning using the Deep Learning approach with KIT Mechanics in facilitating a shift in students' conceptions towards a more scientific understanding of concepts. on the subject of vibrations and waves.

Research methods

This study uses an experimental design. which aims to examine the effect of applying the Deep Learning approach combined with the use of KIT Mechanics on the shift in students' conceptions (i.e., the frequency of misconceptions) regarding vibration and wave materials. This design enables the measurement of changes in conceptions within the same group before and after treatment.

The sub-materials studied include: (1) Analysis of the basic concepts of vibrations and waves and their applications in everyday life, (2) Identification of the differences and relationships between frequency, period, and amplitude, (3) Observation and explanation of the direction of propagation of transverse and longitudinal waves through experiments, (4) Calculation of frequency, period, and number of vibrations in a certain time interval using the Mechanics KIT, (5) Explanation of the relationship between wavelength and wave propagation speed based on experimental results and influencing factors.

The research was conducted at SMP Negeri 10 Gorontalo, involving three classes: the experimental class, replication class 1, and replication class 2, with a total of 69 students as the research sample, determined using the total sampling technique. The variables in this research are the independent variable (intervention), application of the Deep Learning approach in learning, and the use of Mechanics KIT as a demonstration medium, and the dependent variable, frequency of student misconceptions on vibration and wave material, measured based on conception categories (MB, TPK, M, PK).

Deep Learning approach is realized in learning activities that involve: exploration through experiments using the Mechanics KIT, recording observation results, reflection on initial predictions, group discussions to elaborate on the differences between predictions and experimental data, preparation of concept maps, and presentation of group work results. The series of activities is designed to stimulate the association of new concepts with prior knowledge, encourage higher-order thinking, and facilitate conceptual reconstruction, so that they not only focus on laboratory procedures but also foster in-depth conceptual understanding [23].

This research instrument employs a three-tier diagnostic test in multiple-choice format, consisting of 10 items, administered as a pretest. before treatment and *post-test* after treatment. Each item consists of the following components: Tier 1: answer choices (conceptual), Tier 2: reasons/explanations (structured according to reason options), and Tier 3: confidence level. Classification of answer results follows the following categories: Concept Understanding (PK), Misconception (M), Concept Not Understanding (TPK), and Guessing (MB).

The validity and reliability of the learning tools, namely worksheets, modules, teaching materials, and questions, have been validated by material experts and science education practitioners. The validity coefficient value ranges from 78.12% to 96.15% (classified as valid to very valid) [11].

Data analysis was carried out using the SPSS application to statistically analyze changes or transitions in students' conceptions, in line with the descriptive hypothesis regarding transitions in students' conceptions based on the results of the difference between the pretest and posttest in each class.

Through this analysis, a more comprehensive picture was obtained regarding the shift in students' conceptions, specifically the transition from less accurate conceptions to a more scientific understanding, as a result of applying the Deep Learning approach and utilising the Mechanics KIT on the material of vibrations and waves. Based on the results of the calculations in SPSS, the experimental class can be said descriptively that good data characteristics improve students' conceptual understanding.

To clarify the analysis of the results of the three-tier diagnostic test, this study presents a visualization of the direction of shifts in students' conceptions. using colored arrow symbols and circle marks. This visualization is used to show changes in student conceptions from pretest to posttest results more concretely. Upward arrow (↑) blue indicates an increase in conception, namely a change from a low understanding category to a more scientific category (for example, from Misconception to understand the concept*).* Instead, arrow down (↓) red shows a decline in conception, namely a change from scientific understanding to a lower category of conception (for example, from Understanding the Concept *to* Not Understanding the Concept *or* Misconception. While the circle symbol (O) is yellow indicates that there is no change in conception, meaning that students' understanding remains the same before and after learning.

As a form of in-depth analysis, the direction of student conceptual shifts from the pretest to the posttest is presented in a visual table format. This presentation aims to facilitate readers' understanding of the pattern of student conceptual change for each test item presented in Table 1.

Table 1. Changes in students' conceptions

No	Respondents	Question Items									
		1	2	3	4	5	6	7	8	9	10
1	Respondent 1	BBY ↑ SBY	BBY ↑ SSY	BBY ↑ SBY	BBY ↑ SST	BBY ↑ BSY	BBY ↑ SSY	BSY ↓ SST	BBY ↑ SSY	SSY ↓ SST	BBY ↑ BSY
2	Respondent 2	BBY ↑ SBY	BBY ↑ BST	BBY O BBY	BBY ↑ SSY	BBY ↑ SST	BBY ↑ SST	BBY ↑ BSY	BBY ↑ SST	BBY ↑ BSY	BBY ↑ BSY
3	Respondent 3	BBY ↑ SSY	BSY ↓ BST	SBY ↓ SBT	BBY ↑ SSY	SBT O SST	SST O SBT	BSY O SSY	BBY ↑ SBT	BBY ↑ SSY	BST O BST
4	Respondent 4	BBY ↑ SBY	BSY O SSY	BBY ↑ SBY	BBY O BBY	BBY ↑ SBT	BBY ↑ BSY	BBY O BBY	BBY ↑ SBT	BBY ↑ SST	BBY ↑ BSY

Model analysis is used as a quantitative framework to represent the condition of students' conceptual understanding, namely, the consistent use of scientific concepts, the use of misconceptions, or mixed conditions when students still use both types of understanding in different contexts [24].

In addition to the arrow symbol, the combination of student answer results in the three-tier diagnostic test is also represented in a three-letter code, which describes the level of correctness of the student's answer, reasoning, and belief. The first letter indicates the concept answer (B = True*,* S = False)*, and* the second letter indicates the reason or explanation. (B = True*,* S = False), and the third letter indicates the student's level of confidence (Y = Yes, T = No). The meaning of each code is explained in Table 2.

Through the use of colored arrow symbols and three-letter codes, the direction and quality of students' conceptual shifts can be seen more clearly, so that the analysis not only describes changes in quantitative scores, but also shows the dynamics of students' conceptual understanding during the Deep Learning-based learning process with the help of KIT Mekanika. These findings support the constructivist theory of conceptual change, which posits that conceptual change occurs when students experience cognitive conflict between their prior knowledge and new scientific information [25]. The Deep Learning learning process creates these conditions by providing space for scientific exploration, reflection, and discussion.

Table 2. Answer Codes and Student Conception Categories

No.	Answer Code	Conception Category	Information
1.	BBY	Concept Understanding (PK)	Correct answer, correct reason, and confident in your choice)
2.	BSY	Misconception (M)	Correct answer, wrong reason and confident in his choice.
3.	SBY	Misconception (M)	Wrong answer, correct reason, and confident in his choice.
4.	SSY	Misconception (M)	Wrong answer, wrong reason, and confident in his choice.
5.	BBT	Guess (M)	Correct answer, correct reason, but not sure about the choice.
6.	BST	Don't Understand the Concept (TPK)	Correct answer, wrong reason, and not sure about the choice.
7.	SBT	Don't Understand the Concept (TPK)	Wrong answer, correct reason, and not sure about the choice.
8.	SST	Don't Understand the Concept (TPK)	Wrong answers, wrong reasons, and not sure about the choice.

In addition, the use of the Mechanics KIT provides a concrete visual representation of abstract concepts, such as the direction of wave propagation and the relationship between frequency and period. This visual representation makes it easier for students to build accurate mental models and fosters confidence in correct understanding.

The findings of this study align with the results of previous studies, which indicate that the use of physics teaching aids can enhance conceptual understanding and reduce misconceptions [16]. The findings of this study are in line with the results of studies, which state that the use of physics teaching aids can strengthen conceptual understanding and reduce misconceptions [13].

Overall, the results of this study indicate that the combination of the Deep Learning approach and the use of the Mechanics KIT can facilitate significant conceptual changes in students, transitioning from an erroneous understanding to a scientific understanding. This learning model is effective in creating meaningful learning experiences and increasing students' activeness in constructing their own knowledge.

Results and Discussion

The results of the study indicate that the application of the Deep Learning approach, assisted by the Mechanics KIT, has a significant impact on the shift in conceptions of eighth-grade junior high school students regarding the topic of vibrations and waves. The shift in conceptions in question is a change in the category of student understanding from 'Guessing' (MB), 'Misconception' (M), and 'Don't Understand the Concept' (TPK) towards the 'Understand the Concept' (PK) category.

The instrument used was a 10-item Three-Tier Diagnostic Test, which allows for a more comprehensive identification of students' level of understanding through analysis of answers, reasons, and level of confidence. Before further analysis of the shift in student conceptions, the difference between pretest and posttest scores in the experimental class was analyzed using SPSS to determine the data distribution. The analysis revealed that the data were normally distributed, indicating no significant deviations.

The pretest and posttest data were analyzed through calculations using SPSS to determine the data distribution pattern. The calculation results showed that the difference between the pretest and posttest scores in replication class 1 was normally distributed. This condition indicates that the data distribution in replication class 1 was relatively uniform and did not exhibit any significant deviation tendencies in distribution.

The calculation results show that the difference between pretest and posttest scores in replication class 2 is normally distributed. This condition indicates that the distribution of data in replication class 2 is relatively uniform and does not exhibit any significant deviation tendencies in its distribution. This indicates that the data distribution pattern in replication class 2 does not show any extreme deviations and has a tendency towards a relatively balanced distribution.

The characteristics of data distribution are used only as supporting information, as this study focuses on the descriptive analysis of changes in students' conceptions, rather than testing differences or statistical hypotheses.

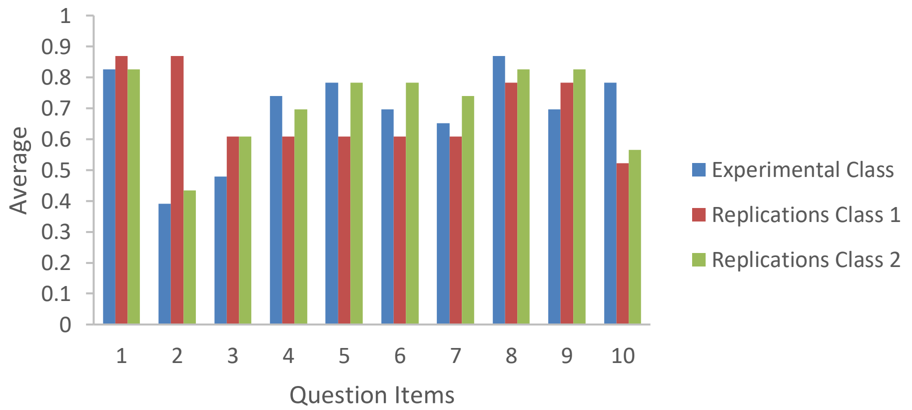

Figure 1. Average Conceptual Change in Experimental Class, Replication 1 and Replication 2

In Figure 1, based on the difference between the pretest and posttest values, all three classes showed a positive shift in student conceptions across nearly all test items. Most items had moderate to high conceptual change scores, indicating that the learning process was effective in helping students understand the concepts of vibrations and waves. In addition, the pattern of conceptual changes shown by the experimental class, replication 1, and replication 2 was relatively similar. This suggests that the implementation of learning has a consistent impact on encouraging students in each class to develop a deeper conceptual understanding.

In addition, the shift in student conceptions per item in the Experimental class is indicated by a blue arrow symbol (↑), which indicates an increase in the dominant conception in almost all test items, with a total of 65 changes towards a higher direction. Meanwhile, the red arrow symbol (↓), which shows a decrease in conception, only appears as many as 7 times, and the symbol yellow circle (O), which indicates no change in conception, appeared 18 times.

The most conceptual changes occurred in the concepts of the relationship between frequency, period, and amplitude (questions 2 and 5), while the least change was found in the concept of the direction of longitudinal wave propagation (question 9). Students with the highest shift in conception (from the TPK or M category to PK) included respondents 4, 16, and 17, while the student with the lowest change was respondent 21. which still shows fluctuations between the TPK and M categories.

In general, these results indicate that learning with the Deep Learning approach, assisted by the Mechanics KIT, effectively enhances conceptual understanding, particularly in indicators that require analysis of the relationship between physical quantities.

In replication class 1, there is a blue arrow symbol (↑) which dominates almost all questions, with a total of around 62 times the increase in conception. The red arrow symbol (↓) appears about 8 times, and the yellow circle symbol (O) appears 20 times. The biggest shift in conception occurred in the concept of frequency and period of vibration (questions 4 and 5), where most students experienced an increase from the category of misconception to understanding the concept. The lowest change was found in the concept of the direction of propagation of transverse waves (question number 9), which still shows misconceptions among some students.

Students with the highest increase in conception included respondents 2, 3, and 16, while respondents 15 and 11 showed the lowest increase, yet still exhibited fluctuations in understanding.

Overall, replication class 1 demonstrated that the deep learning-based learning process, combined with hands-on experiments using the Mechanics KIT, successfully encouraged students to reflect on misconceptions and strengthen their scientific understanding of the concepts of vibration and waves.

In Replication class 2, the blue arrow symbol (↑) still dominates with a total of around 60 times the increase in conception, while the red arrow symbol (↓) only appears 6 times, and the yellow circle symbol (O) appears 24 times.

The most significant changes in conception occurred in the concepts of transverse and longitudinal waves (questions 3 and 6), which, after learning, showed a notable shift from the category of misconception (M) to understanding the concept (PK). The least changes occurred in the concept of the relationship between speed of propagation, wavelength, and frequency (questions 8 and 10), because it requires higher mathematical analysis skills.

Students who experienced the highest increase in conception included respondents 6, 16, and 20, while students with the lowest increase were respondents 5 and 17. These results indicate that deep learning-based learning is able to create positive changes in conception, even in classes with diverse student characteristics, because students are actively involved in exploring and reflecting on the results of experiments using the Mechanics KIT.

These findings reinforce the constructivist theory of conceptual change, which explains that conceptual change occurs when students experience cognitive conflict between prior knowledge and new scientific information [25] . The Deep Learning learning process creates these conditions by providing space for scientific exploration, reflection, and discussion.

Additionally, the use of the Mechanics KIT provides concrete visual representations of abstract concepts, such as the direction of wave propagation and the relationship between frequency and period. This visual representation facilitates students' development of accurate mental models and fosters confidence in their understanding.

The findings of this study align with those of previous studies, which suggest that the use of physics teaching aids can enhance conceptual understanding and reduce misconceptions. [16]. The findings of this study are in line with the results of studies, which state that the use of physics teaching aids can strengthen conceptual understanding and reduce misconceptions [13].

Overall, the results of this study indicate that the combination of the Deep Learning approach and the use of the Mechanics KIT can facilitate significant conceptual changes in students, transitioning from an erroneous understanding to a scientific understanding. This learning model is effective in creating meaningful learning experiences and increasing students' activeness in constructing their own knowledge.

Conclusion

Based on the research results, it can be concluded that the application of the Deep Learning approach and the Mechanics KIT can facilitate a shift in the conceptions of eighth-grade junior high school students on the topic of vibrations and waves towards a more scientific understanding. The shift in conceptions is indicated by the dominance of changes in the categories of student understanding, from "Guessing" (MB), "Not Understanding the Concept" (TPK), and "Misconception" (M) to "Understanding the Concept" (PK), in both the experimental class and the replication class. The results of descriptive analysis using SPSS on the difference in pretest and posttest scores across the three classes indicate that the data are normally distributed and have a relatively uniform distribution, thereby supporting the consistency of the observed pattern of conceptual shifts. The dominance of the blue arrow symbol (↑) in the analysis results for each class shows a consistent increase in conceptions, with the most prominent shift occurring in the concept of the relationship between frequency, period, and amplitude of vibration, while a relatively lower shift was found in the concept of the direction of longitudinal wave propagation. Overall, these findings suggest that integrating the Deep Learning approach with the Mechanics KIT is effective in reducing the frequency of misconceptions and supporting the reconstruction of students' conceptual understanding in science learning.

Author's Contribution

Sukmawati played a role in preparing the research design, collecting data, analysing the results, and writing the article manuscript. Asri Arbie acted as the main supervisor, providing scientific guidance, methodological direction, and substantive corrections to the article content. Both authors have read and approved the final manuscript for publication.

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