Identifying High School Students' Misconceptions Using Digital Four-Tier Diagnostic Tests in Distance Learning

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Abstract. The pandemic of the spread of a new virus, namely the corona virus disease (Covid-19) in Indonesia, has forced the government to use an education virtualization system which has been expanded into online learning or distance learning. This makes it difficult for teachers to identify how big the misconceptions experienced by students in Physics subjects with harmonious vibration material during learning take place, so teachers and students need an online assessment instrument that is able to identify the student's misconceptions. This study aims to analyze the misconceptions of high school students using a digital four-tier diagnostic test in distance learning. The method used is a single case study. The research analysis used the Rasch model. The instrument used is a conceptual understanding test using a digital four-tier diagnostic test instrument which consists of 10 questions on the Harmonic Vibration material to identify students' misconceptions. This research was conducted in three stages; (1) the planning stage, (2) the implementation stage, and (3) the final stage. Based on the results of data analysis, there is a percentage of students who understand the concept of 54%, 23% less understanding of the concept, 21% of misconceptions, and 2% non-code (error). The average value of misconceptions experienced by students shows a low category for Harmonic Vibration material.

1. Introduction

In the 21st century, students are required to have four competencies in themselves, namely conceptual understanding, critical thinking, creative thinking and collaboration and communication [1]. Physics is a part of science that emphasizes mastery of concepts. In learning physics, it is directed to find out so that it can help students to gain in-depth mastery of concepts [2]. Mastery of concepts is one of the objectives of physics subjects in high school. These objectives are stated in the Education Unit Level Curriculum (KTSP), namely so that students have the ability to master the knowledge, concepts and principles of physics [3]. Mastery of concepts becomes very important for students because it is included in the indicators where students have fully understood what has been taught, not just memorizing. So that later mastery of this concept can help students in solving problems, not only in the learning process but also in everyday life. Therefore, teachers need to direct students' understanding of the concepts of the material being taught.

However, the World Health Organization (WHO) stated that in 2019, the world is being faced with a pandemic of the spread of a new virus, namely the corona virus disease (Covid-19). The nature of this virus is highly contagious, social distancing and lockdowns have become unavoidable to prevent its rapid spread in society [4]. One of the areas most affected by this pandemic is education. To reduce the number of transmission of the virus, teaching and learning activities in schools must be temporarily suspended. Then, the government made a policy that the implementation of education needed to use an
educational virtualization system which was expanded into Distance Learning [5]. Online learning is an effective way as a new avenue for science and technology education and has accelerated educational globally especially during the pandemic [6]. So the Indonesian government decided to organize online learning or Distance Learning (PJJ) through the use of various communication media in accordance with the policies set by the government.

Based on the explanation above, this situation has an impact on students' misconceptions or misconceptions in receiving the material. Misconceptions that occur in students vary with different causes [7]. Conceptual errors or misconceptions are errors in interpreting concepts or not in accordance with scientific concepts that have been believed and applied by experts [8]. The causes of student misconceptions, mostly come from the students themselves, namely students' inadequate prior knowledge and lack of motivation to learn [9]. Misconceptions can be a barrier to organizing knowledge so it needs to be addressed properly [10]. Misconceptions occur if students have a high level of confidence in a concept that is considered wrong [11] where the wrong concept is not in accordance with the scientific understanding or understanding accepted by scientists in the field concerned, especially physics [8]. Misconception can also be interpreted as a contradiction or incompatibility of the concept understood by someone with the concept used by the expert in science [12] or a preconception that is not in accordance with the scientific conception [13]. Thus, the outline of misconceptions is a form of inaccurate understanding of a concept which is characterized by (1) students being inaccurate in accepting concepts, (2) using wrong concepts, (3) classifying examples of incorrect questions, (4) confusion of different concepts, and (5) the relationship of the concepts does not match.

Based on previous research conducted by Kharisma Fenditasari, the results showed that the value of misconceptions on one of the physics topics was 61.5% [14]. Subsequent research was conducted by Islami et al. The results showed that 47% of students had misconceptions, 7% of the students understood the concept, 36% of students did not understand and 10% of students had errors [15]. Then the research conducted by Zulfikar et al, the results showed that the level of comprehensive understanding was 20%, the level of partial understanding was 27%, misconceptions were 40% and the level of understanding did not understand was 3% [16]. Efforts to identify students' misconceptions must distinguish between students who experience misconceptions and students who do not know the concept. One way to find out misconceptions in students is with a diagnostic test. The four-tier diagnostic test is an extension of the three-tier multiple-choice diagnostic test [17]. The first level is a multiple choice question with three distractors and one answer key, the second level is the level of students' confidence in choosing the answer, the third level consists of three choices of reasons that have been provided and one open reason, the fourth level is the level of students' confidence in choosing reasons [18]. From these results, it is believed that the four-tier diagnostic test item can be implemented as an effective learning strategy to identify students' misconceptions.

In general, the steps that can be used to help students overcome misconceptions are looking for the form of the misconception they have, looking for the cause and determining the appropriate way [19]. Misconceptions cannot be generalized directly because the forms of misconceptions that occur can be different or the same [20] especially with the current distance learning. The misconceptions experienced by students must be understood and discovered by teachers in order to help students improve the misconceptions they experience effectively. However, there are still few teachers who pay attention to how to identify and resolve students' misconceptions. Not only students, teachers are also required to create new innovations in learning and assessment. The creativity of teachers in conducting assessments is the main element in evaluating the ongoing online learning process. One of the new innovations in assessment is the media. Google Forms is a useful digital tool to help plan events, send surveys, give quizzes or collect easy information in an efficient way [21]. Therefore, we need a digital test instrument that can help teachers to identify misconceptions innovatively and effectively. Thus, the purpose of this study was to analyze the misconceptions of high school students using a digital four-tier diagnostic test in distance learning.
2. Method

This research is a single case study. A case study is a model that focuses on exploring a "bounded system" on one case or in some cases in detail with in-depth data mining [22]. The research analysis was carried out using the Rasch model through a conceptual understanding test using a digital four-tier test instrument to identify the misconceptions of high school students where the digital media used were Google Form. This preliminary case study was attended by 126 students of class X SMA in Tangerang City. Student research subjects were selected purposefully, namely subjects who have competencies based on data needs that can support the achievement of research objectives [20]. The data were collected by conducting a concept understanding test in the form of a four-tier diagnostic test of 10 questions on the material of harmonic vibrations.

This case study was conducted in three stages; (1) planning/preparation stage, conducting visits to schools for research permits, contacting physics teachers to determine research time, determining sampling, preparing preliminary case study instruments, (2) implementation stage, giving students' concept understanding tests at home to identify students' misconceptions, and (3) the final stage, processing research data, discussing and analyzing data, providing conclusions and recommendations [22]. The data processing technique was carried out quantitatively in the form of students' conceptual understanding test scores using a digital four-tier diagnostic test to identify students' misconceptions which were analyzed by statistical tests to describe the percentage of students' misconceptions. The analysis technique uses the Rasch model, where the principle of this model uses the principle of probability for each available option in accordance with classical test theory which prioritizes the total value of the test results. In this study, Winstep software was used to process the data obtained from the results of the students' concept understanding test. Calculation of the percentage of students' misconception scores by [23]:

\[
\text{average score percentage} = \frac{\text{score obtained}}{\text{maximum score}} \times 100\% \quad (1)
\]

Then, the percentage is interpreted according to Table 1. below:

| Percentage (%) | Category |
|----------------|----------|
| 61-100         | High     |
| 31-60          | Medium   |
| 0-30           | Low      |

In addition to indicators of interpretation of misconceptions, other data used to identify students' misconceptions are; (1) the reliability of the instrument, in Table 2. There are criteria for the reliability of the instrument using the Cronbach alpha value in the Rasch Model. The analysis was applied to the data obtained from tests and student response questionnaires.
Table 2. Instrument Reliability Criteria

| Interval          | Criteria  |
|-------------------|-----------|
| RC-20 < 0.67      | Weak      |
| 0.67 < RC-20 < 0.8| Enough    |
| 0.8 < RC-20 < 0.9 | Good      |
| 0.91 < RC-20 < 0.94| Very Good |
| RC-20 > 0.94      | Excellent |

(2) the level of difficulty, the index of difficulty is calculated by the formula [2]

\[ P = \frac{B}{J_s} \]  \hspace{1cm} (2)

With description; \( P \) is the level of difficulty, \( B \) is the number of students who answered correctly, \( J_s \) is the total number of students. Table 3. shows the classification of the level of difficulty of the questions.

Table 3. Classification of Problem Difficulty Levels

| Classification | Criteria |
|----------------|----------|
| \( P < 0.30 \) | Hard     |
| \( 0.30 \leq P \leq 0.70 \) | Medium |
| \( P > 0.70 \) | Easy     |

(3) differentiating power, the ability of questions to distinguish students with high abilities from those with low abilities [2]. The index used in distinguishing them is the index of discriminating power. The formula used to determine the discrimination index is as follows:

\[ D = \frac{B_a}{J_a} - \frac{B_b}{J_b} \]  \hspace{1cm} (3)

With description; \( D \) is the value of distinguishing power, \( B_a \) is the number of the upper group who answered correctly, \( B_b \) is the number of the lower group who answered correctly, \( J_a \) is the number of participants in the upper group, \( J_b \) is the number of the lower group participants. In Table 4. the following shows the classification of the difference power index of the questions.

Table 4. Classification of Differentiating Power Index Questions

| Differing Power Index | Criteria |
|-----------------------|----------|
| 0.00 – 0.20           | Bad      |
| 0.20 – 0.40           | Enough   |
| 0.40 – 0.70           | Good     |
| 0.70 – 1.00           | Very Good|
3. Result and Discussion

This research was applied to 126 students of class X SMA in Tangerang City. The test consists of 10 multiple choice questions at four levels using Google Form. This test instrument is equipped with reasons and the level of student confidence in doing the test. The analysis technique of the test instrument used the Rasch model, which obtained several categories including the reliability value of the questions, the level of difficulty and the discriminating power of the questions.

Through this analysis, the results of personal reliability are 0.16 and item reliability is 0.89. From these results it was concluded that the consistency of the answers from students was weak, but the quality of the items in the instrument's reliability aspect had good criteria. Cronbach's alpha value to measure the reliability of the interaction between the person and the items is 0.08. The alpha value indicates that the reliability of the test in general is still not satisfactory and is in the weak category. In the analysis of the Rasch model, the level of difficulty of the test instrument can be seen based on the measure column in the Winstep software.

![Figure 1. Column Measure in Rasch Model by Winsteps Program](image)

In Figure 1, above shows the logit value for each item sorted from highest to lowest by Winsteps Program. For item 1, which is 3.95 logit, it shows the most difficult item, while item 3 is the easiest item at -2.43 logit. Likewise, the discriminatory power of questions can be seen from the distribution of questions. The order of distribution of questions according to the level of difficulty. Students with low abilities consist of 21 people with person codes 07, 15, 22, 24, 27, 30, 39, 42, 43, 48, 52, 65, 73, 97, 107, 111, 116, 118, 121, 124 and 125. Students with high abilities consist of 9 people with person codes of 01, 03, 11, 25, 36, 67, 78, 82 and 93. The data on the results of the diagnostic test of misconceptions using digital four-tier diagnostic test questions are grouped and counted. Students who are included in the category of understanding concepts, do not understand concepts and misconceptions so that the results are obtained as shown in Table 5.
Table 5. Number of Students by Category

| No. Item | Total students |
|----------|----------------|
|          | UC  | NUC | M   | E   |
| 1        | 107 | 19  | 0   | 0   |
| 2        | 115 | 11  | 0   | 0   |
| 3        | 87  | 13  | 24  | 2   |
| 4        | 102 | 20  | 2   | 2   |
| 5        | 35  | 9   | 82  | 0   |
| 6        | 82  | 17  | 23  | 4   |
| 7        | 97  | 18  | 11  | 0   |
| 8        | 22  | 35  | 63  | 6   |
| 9        | 31  | 70  | 18  | 7   |
| 10       | 2   | 78  | 45  | 1   |
| Total    | 680 | 290 | 268 | 22  |
| Percentage| 54% | 23% | 21% | 2%  |

UC is conceptual understanding, NUC is not understanding the concept, M is misconception and E is the error.

From Table 5. above, students are grouped into four groups for each sub-concept. The percentage data from these are shown in Table 6.

Table 6. Percentage of Results of UC, NUC, M and E data analysis

| Sub Concept                        | Percentage | Interpretation |
|------------------------------------|------------|----------------|
|                                    | UC | NUC | M | E | Misconception |
| Harmonic Motion on the Pendulum    | 85 | 15  | 0 | 0 | Low            |
| Simple Pendulum System Period and Frequency | 91 | 9   | 0 | 0 | Low            |
| Spring Period and Frequency        | 69 | 10  | 19 | 2 | Low            |
| Harmonic Vibration Deviation       | 81 | 15  | 2 | 2 | Low            |
| Harmonic Vibration Speed           | 28 | 7   | 65 | 0 | High           |
| Harmonic Vibration Acceleration    | 65 | 14  | 18 | 3 | Low            |
| Kinetic Energy of Harmonic Motion  | 77 | 14  | 9 | 0 | Low            |
| Harmonic Motion Potential Energy   | 17 | 28  | 50 | 5 | Medium         |
| Harmonic Motion Mechanical Energy  | 25 | 56  | 14 | 5 | Low            |
| The Speed of Harmonic Vibrating Objects | 2 | 61  | 36 | 1 | Medium         |

From the data that has been obtained, Table 6. shows the percentage of analysis results of students who understand concepts, do not understand concepts, misconceptions and errors in the concept of harmonic vibration using a digital four-tier diagnostic test with Google Form media. While in Table 6.
shows the percentage of the results of data analysis of students' misconceptions and their interpretation. Based on these data, it could be seen that in the sub-concept of harmonic motion of a pendulum (item number 1), students experience 0% misconceptions with low interpretations. In the sub-concept of the period and frequency of the simple pendulum system (item number 2), students experience 0% misconceptions with low interpretations. In the period and frequency sub-concepts on the spring (item number 3), students experienced 19% misconceptions with low interpretations. In the sub-concept of harmonic vibration deviation (item number 4), students have misconceptions of 2% with low interpretation. In the sub-concept of the speed of harmonic vibrations (item number 5), students experience a misconception of 65% with a high interpretation. In the sub-concept of harmonic vibration acceleration (item number 6), students have 18% misconceptions with low interpretations. In the sub-concept of harmonic motion kinetic energy (item number 7), students have 9% misconceptions with low interpretations. In the sub-concept of potential energy of harmonic motion (item number 8), students experience a misconception of 50% with a moderate interpretation. In the sub-concept of harmonic motion mechanical energy (item number 9), students experience misconceptions by 14% with low interpretation. In the sub-concept of the speed of objects that vibrate harmonics (item number 10), students experience misconceptions by 36% with low interpretation.

Based on the tests carried out using a digital four-tier diagnostic test to identify students' misconceptions, it can be seen in Table 7, which shows the highest value, namely in item number 5, namely the sub-concept of harmonic vibration speed and the lowest value in item number 1, namely harmonic motion on a pendulum. Item number 2, namely the period and frequency on a simple pendulum. After the implementation of the digital four-tier diagnostic test instrument, the highest results were obtained in question number 5 with the sub-concept of harmonic vibration speed of 65%, while the lowest results were in question number 1 with sub-concept of harmonic motion on a pendulum of 0% and question number 2 with sub-concept period and frequency on a simple pendulum is 0%. In Table 5, the average value of misconceptions experienced by 126 students is 21%. This shows that the misconceptions about the concept of harmonious vibration for class X SMA in Tangerang City are included in the low category. Based on the presentation of the results of data analysis using the Rasch model that has been carried out, it states that the digital four-tier diagnostic test instrument is very effective in identifying the misconceptions of class X high school students in the Tangerang City on the material of harmonic vibrations.

The results of data analysis and discussion, it can be concluded that students are divided into four groups, namely understanding concepts, not understanding concepts, misconceptions and non-codes (errors). The category of students who understand the concept is moderate, lack of conceptual understanding is low, misconception is low and non-code (error) is low. The category of the highest percentage value of misconceptions is in item number 5 with the sub-concept of harmonic vibration speed while for the category of the lowest percentage value of misconceptions is found in item number 1 with sub-concept of harmonic motion on the pendulum and item number 2 with the sub-concept of period and frequency on the pendulum. The category of the average percentage of misconceptions in class X high school students in Tangerang City is low.

4. Conclusion
The pandemic of Covid-19 makes it difficult for teachers to identify how big the misconceptions experienced by students in Physics subjects with Harmonic Vibration material during learning take place, so teachers and students need an online assessment instrument that is able to identify the student's misconceptions. This study aims to analyze the misconceptions of high school students using a digital four-tier diagnostic test in distance learning. The method used is a single case study. The research analysis used the Rasch model by Winsteps Program. The instrument used is a conceptual understanding test using a digital four-tier diagnostic test instrument which consists of 10 questions on the Harmonic Vibration material to identify students' misconceptions. This research was conducted in three stages; (1) the planning stage, (2) the implementation stage, and (3) the final stage. Based on the results of data analysis, there is a percentage of students who understand the concept of 54%, 23% less understanding
of the concept, 21% of misconceptions, and 2% non-code (error). The average value of misconceptions experienced by students shows a low category for Harmonic Vibration material.

Suggestions that can be put forward after the case study is carried out to improve students' conceptual understanding by conducting practicum or changing methods, models or approaches that emphasize students' ability to understand concepts in depth. Thus, students have a sense of responsibility to learn the concept of Harmonic Vibration material well.

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