An analysis of student’s concepts understanding about simple harmonic motion: Study in vocational high school

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Abstract. This study presents an analysis of the student’s concept of understanding about simple harmonic motion in vocational high school. The sample of the study consisted of 76 vocational high school students 1 Mondokan. The two-tier research instrument used to measure students' understanding of concepts. The category of concept understanding assessment based on concept understanding indicators, i.e., no understanding, specific misconception, partial understanding with a specific misconception, partial understanding, and sound understanding. The results of the analysis of the quality of the instrument indicate the value of person reliability of 0.82, and item reliability of 0.76 is in a good category. The results showed that specific misconception was 14.6%, partial understanding with a specific misconception was 23.9%, partial understanding was 36.8%, and sound understanding was 24.7%. These findings indicate the need to empower students’ understanding of concepts, using instructional media that can visualize abstract concepts of simple harmonic motion.

1. Introduction
The development of scientific physics from year to year continues to experience development in accordance with the times [1], [2]. Because the development of that era is what drives humans to be more critical and creative in developing or implementing Physics as one of the basic sciences. One part of the development of physics science in question is the problem of learning physics. Physics learning is very necessary because it is related to the understanding of concepts in students. Students who will later contribute in the further development of Physics or in applying Physics in everyday life [1].

General problems that occur in learning Physics, namely students are less encouraged to develop their thinking skills [3]. General problems that occur in learning Physics, namely students are less convinced to develop their thinking skills [4]–[6] which is able to empower students to understand the concepts of Physics. Physics learning is carried out in class, only directing students in using equations, memorizing equations, working on problems, rarely taught to analyze and implement physics in everyday life [7].

Physics learning like this makes students do not have a good understanding of physics concepts. As a result, when students are given problems that require critical and creative thinking skills or problems that are different from the example problems cannot be solved properly. Understanding of concepts is influenced by a set of ideas, procedures, principles, or physical laws that are understood holistically if they form a pattern with high relevance. In other words, understanding the concept of physics is the basis for thinking in solving problems in the form of theoretical physics or its implementation in everyday life.
Students are said to understand concepts if they are able to define concepts, identify and give examples, develop Physics connection skills from various points of view, and understand how Physics ideas are interrelated with one another. The oldest physics theory is mechanics that studies the motion of a system or thing [6]–[8]. The movement of systems or objects that occur repeatedly in the same time interval is called periodic motion, the movements occur regularly [8]. This movement is called simple harmonic motion (GHS) [9].

GHS material that is studied in education units at the secondary level varies, depending on the objectives to be achieved. Senior High School (SMA) is an educational unit that is a place for the development of quality and quality of students who prioritize terrorist abilities in the hope of becoming a graduate who is able to contribute to the development of the knowledge he learns [2].

Vocational High School (SMK) is an education unit that places more emphasis on practical matters rather than theoretical [1], [10], [11], so the concept of simple harmonic motion in vocational schools is not as deep as that learned by high school students. Based on the curriculum applicable at the vocational school, the GHS sub material studied consists of the Amount of GHS, GHS on springs, and GHS on pendulum. Even so, vocational students are still required to be able to use their theories and apply them in the industrial field.

2. Methods
This research is a quantitative descriptive study, used to explain the results of the analysis of the understanding of the concept of students at the Vocational High School 1 Mondokan in simple harmonic motion material. The instrument used was in the form of a two-tier test of 20 items, consisting of two levels. At the first level contains multiple-choice for the choice of answers to questions, the second level there are reasons for choosing answers [4]. The distribution of questions used in this study is presented in Table 1.

| No | Sub Material                             | Question Number |
|----|------------------------------------------|-----------------|
| 1  | Magnitude on Harmonic Motion             | 1, 2, 3, 4, 5, 6|
| 2  | Simple Harmonic Motion on a spring       | 7, 8, 9, 10, 11, 12 |
| 3  | Simple Harmonic Motion in Pendulum       | 13, 14, 15, 16, 17, 18, 19, 20 |

This instrument is used to determine the level of understanding of students' concept of learning material after they have finished following a series of physics learning. The test is given in the form of two tiers, so that it can cover all subject matter. Analysis of test reliability. Two tier instruments were analyzed for quality using the Quebec User Evaluation of Satisfaction with Assistive Technology (Quest).

The validity of the instrument is determined through content validity using expert agreement. This is because the measurement instrument is proven valid if the expert believes that the instrument is able to measure the mastery of a predetermined ability. Instrument validity analysis techniques using the Aiken formula [12], i.e:

\[
V = \frac{\sum s}{n (c-1)}
\]

V values range from 0-1 and the criteria used to declare an instrument are said to be content valid on the number of rater (assessors) of 9 people based on the Aiken Table [13] is 0.74. Samples used in the study were 76 students in the 2018/2019 school year. The scoring used refers to Abraham's theory [14], as in Table 2. The categories used in understanding concepts consist of five categories, among them no understanding, specific misconception, partial understanding with a specific misconception, partial understanding, and sound understanding.
Table 2. Evaluation Scheme for Concept Test Items [14]

| Numerical Score | Degree of Understanding                          | Criteria for Scoring                                                                 |
|-----------------|--------------------------------------------------|---------------------------------------------------------------------------------------|
| 1               | Specific misconception                           | Scientifically incorrect responses                                                   |
| 2               | Partial understanding with a specific misconception | Responses that show understanding of the concept, but that also contain a misconception |
| 3               | Partial understanding                           | Response that contain a part of the scientifically accepted concept                   |
| 4               | Understanding                                   | Response that contain all part of the scientifically accepted concept                 |

3. Result and Discussion

3.1. Quality of the Two Tier Assessment Instrument

The physics concept understanding instrument is in the form of 20 two-tiered multiple-choice questions with 5 alternative choices. Two-tier assessment instruments performed a quantitative validity analysis, using the Aiken formula [11], in equation (1). The results of the validity analysis of each question item are presented in Table 3.

Table 3. Results of Calculation of Content Validity

| Question Number | Score V | V value | Result |
|-----------------|---------|---------|--------|
| 1               | 0.81    | 0.74    | Valid  |
| 2               | 0.74    | 0.74    | Valid  |
| 3               | 0.93    | 0.74    | Valid  |
| 4               | 0.93    | 0.74    | Valid  |
| 5               | 0.89    | 0.74    | Valid  |
| 6               | 0.78    | 0.74    | Valid  |
| 7               | 0.89    | 0.74    | Valid  |
| 8               | 0.74    | 0.74    | Valid  |
| 9               | 0.74    | 0.74    | Valid  |
| 10              | 0.74    | 0.74    | Valid  |
| 11              | 0.85    | 0.74    | Valid  |
| 12              | 0.74    | 0.74    | Valid  |
| 13              | 0.85    | 0.74    | Valid  |
| 14              | 0.74    | 0.74    | Valid  |
| 15              | 0.93    | 0.74    | Valid  |
| 16              | 0.89    | 0.74    | Valid  |
| 17              | 0.74    | 0.74    | Valid  |
| 18              | 0.78    | 0.74    | Valid  |
| 19              | 0.85    | 0.74    | Valid  |
| 20              | 0.74    | 0.74    | Valid  |

The results of the content validity analysis of the 9 validators for the two-tier assessment instrument have a validity value of 0.74 to 0.93. This shows that the content validity value is greater than or equal to the V value of the Aiken Table, so it can be concluded that the entire test item is valid based on the content validity.
The reliability index of the results of the analysis using the QUEST program is indicated by Reliability of estimate. The instrument is said to be reliable if the minimum reliability value for an instrument is 0.60 [15]. The results of the reliability calculation of the two-tier assessment instrument are presented in Figure 1.

![Summary of item Estimates](image)

**Figure 1.** Reliability calculation results

Reliability on the two-tier assessment instrument has a value of 0.93. This shows that the reliability value is greater than 0.6 so that it can be concluded that the two-tier assessment instrument is an instrument that has consistency or constancy in making measurements.

3.2. **Understanding of Student concepts using Two tier assessment instruments**

![Figure 2. Results of Analysis of Understanding the Concept of GHS in Vocational High School](image)

The results of the analysis of students' understanding of concepts in vocational schools show that they are in the category of partial understanding, which is equal to 36.8%. This result is influenced by the use of teaching strategies used by teachers in teaching GHS material. The learning process on GHS material is carried out using a blended learning model. The blended learning model used is a rotation model that is a learning model that integrates online learning face-to-face in the classroom with the supervision of a teacher or educator with the type of rotation model used in this study is the flipped classroom where students receive instructional instructions in an online form outside the classroom and finish it in the classroom with guidance or supervision from the teacher or educator.

3.2.1. **Understanding of students' concepts in the Simple Harmonic Motion Magnitude sub-material**

The number of items used on the sub-material scale on GHS consists of six items, the results of the analysis of students' understanding of concepts in this sub-material are presented in Figure 3.
Figure 3. Results of Analysis of Understanding of Students' Concepts in the GHS Sub-Material Quantities

Based on the picture 3 items that are most easily shown by item 4 are 75.69%, while the most difficult items are shown by item 1 at 64.93%. These results indicate that students' understanding of the concept of the magnitude of the GHS is already above 50%. The items in item 1 are questions in the cognitive domain C4, presented in Figure 4.

Look at the picture below!

Load with mass M is hung on a spring so that it has an equilibrium position (position B) then is pulled by a certain deviation (position A) so that it experiences vibrations A-B-C-B-A-B-C and so on. These vibrations are called harmonic vibrations. The exact definition of harmonic vibration based on the above event is …

A. Movement back and forth on a spring
B. Movement back and forth from bottom to top
C. Objects that move randomly past the point of equilibrium
D. Objects that move back and forth regularly
E. The object's back and forth motion passes through the equilibrium point

Your reason: ........................................

Figure 4. Item of Understanding the Concept of GHS Sub-Material Quantities

About the item indicator on item 1, students are presented with a spring image and a description of the vibration in the spring. It is expected that students can analyze the definition of harmonic vibrations based on the event. Examples of the results of students' answers in this item are presented in Figure 5.
ENGLISH (EN):
Student Answer is D, objects that move back and forth regularly. Because harmonic vibrations are alternating movements of objects through regular equilibrium positions.

Figure 5. Examples of Student Answers on Item 1

Based on the answers of students in Figure 5, shows that the students are in the category of Specific misconception, namely the criteria scientifically incorrect responses [14]. The students' answers only repeat the question, this can be seen from the reasons they give. The correct answer on this item is on the choice of answer E, namely the alternating movement of objects past the point of equilibrium. The movement of objects going back and forth from the point A-B-C-B-A-B-C is an event of alternating motion of objects through the equilibrium position so that the harmonic vibration is the object's alternating motion past the equilibrium point.

3.2.2. Understanding of the concept of students in Simple Harmonic Motion sub material on springs
The number of items used in the simple harmonic motion material in the spring is six items, the results of the analysis of students' understanding of concepts in this sub-material are presented in Figure 6.

Figure 6. Results of Analysis of Students' Understanding of Concepts on the GHS Sub-Spring Material

Based on the picture 6 items that are most easily shown by item 11 are 74.31%, while the most difficult items are shown by item 7 at 68.06%. These results indicate that students' understanding of the concept of GHS on spring is already above 50%. The items in item 7 are questions in the cognitive domain C4, presented in Figure 7.
An object vibrates harmoniously on a spring with an equation $y = 10 \sin (\pi t)$ cm. The speed of the object after $\frac{3}{4}$ seconds is.....

A. $5\pi \sqrt{2}$ cm/s
B. $-5\pi \sqrt{2}$ cm/s
C. $-10\pi$ cm/s
D. $-10\pi \sqrt{2}$ cm/s
E. $10\pi \sqrt{2}$ cm/s

Your reason: ........................................

**Figure 7.** Item of Understanding the Concept of GHS Sub Material on Spring

The question indicator in item 7, students are presented the deviation equation on a spring, is expected to be able to calculate the speed at a certain time. Examples of the results of students' answers in this item are presented in Figure 8.

**Figure 8.** Examples of Student Answers in Item 7

Based on the answers of students in Figure 8, it shows that the students are in the category of partial understanding with a specific misconception [14]. The students answer item 7 in answer A, based on the reasons given there are errors in mathematical operations. Spring speed i.e.:

$$v = \frac{dy}{dt}$$  \hspace{1cm} (2)

Where $y$ is a spring deviation, i.e.:

$$y = A \sin (\omega t)$$  \hspace{1cm} (3)

The deviation equation is known $y = 10 \sin (\pi t)$, and by entering a value of $t$ equal to $\frac{3}{4}$ obtained by the deviation of objects, i.e.:

$$v = \frac{d}{dt} \left[ 10 \sin (\pi t) \right]$$

$$v = 10\pi \cos (\pi t)$$

$$v = -5\pi \sqrt{2}$$  \hspace{1cm} (4)

The speed unit of the object in this problem is cm / s. The inability of students to reduce the velocity equation is an indication of the weakness of mathematical concepts and strategies. This can be overcome by increasing the number of exercises to derive mathematical equations.
3.2.3. Understanding of students' concepts in the Simple Harmonic Motion sub subject in Pendulum
The number of items used in the simple harmonic motion sub-material on pendulum is eight items, the results of the analysis of students' understanding of concepts in this sub-material are presented in Figure 9.

![Figure 9. Results of Analysis of Understanding of Students' Concepts in the GHS Sub Material for Pendulum](image)

Based on the picture 9 items that are most easily shown by item 14 are 73.96%, while the most difficult items are shown by item 19 at 48.96%. These results indicate that students' understanding of the concept of GHS in pendulum is still below 50%. The items in item 19 are questions in the cognitive domain C3, presented in Figure 10.

![A pendulum vibrates harmoniously with amplitude A. When the speed is equal to half the maximum speed, the deviation is ...](image)

**Figure 10. Item of Understanding the Concept of GHS Sub Material in Pendulum**

Indicators item 19, students are presented with a description of amplitude and maximum speed, is expected to calculate the deviation when it has half the maximum speed. Examples of the results of students' answers in this item are presented in Figure 11.

![Figure 11. Examples of Student Answers in Item 19](image)
Based on the students' answers in Figure 11, it shows that the students are in the category partial understanding with a specific misconception [14]. The students answer point 7 in choice B, based on the reasons given there are errors in mathematical operations. Spring speeds are:

$$v = \omega A \cos(\omega t)$$

(5)

By entering a pendulum velocity value of 0.5 from its maximum velocity, a cosine angle of $60^0$ is obtained. By entering this angular value in the deviation equation (3), the magnitude of the deviation is obtained, i.e. $\sqrt{\frac{3}{2}} A$.

4. Conclusion
Physics learning is carried out by only directing students to use equations, memorizing equations, working on problems, making students passive in learning. Physics learning that does not empower thinking skills makes students do not have a good understanding of physics concepts. As a result, when students are given problems that require critical and creative thinking skills or problems that are different from the example problems, they cannot solve them well. The results showed that specific misconception was 14.6%, partial understanding with a specific misconception was 23.9, partial understanding 36.8%, and sound understanding 24.7%. These findings indicate the need to empower students' understanding of concepts, using instructional media that can visualize abstract concepts of simple harmonic motion.

References
[1] S. R. Hakim, R. Kustijono, and E. Wiwin, “The use of android-based teaching materials in physics learning process at vocational high school,” J. Phys. Conf. Ser., vol. 1171, no. 1, 2019.
[2] S. Sudirman, “The role of vocational education in science and technology development in the era of globalisation,” J. Phys. Conf. Ser., vol. 970, no. 1, 2018.
[3] B. B. Yazar Soyadı, “Creative and Critical Thinking Skills in Problem-based Learning Environments,” J. Gift. Educ. Creat., vol. 2, no. 2, pp. 71–71, 2015.
[4] H. Affandy, N. S. Aminah, and A. Supriyanto, “The correlation of character education with critical thinking skills as an important attribute to success in the 21st century,” in Journal of Physics: Conference Series, 2019, vol. 1153, no. 1.
[5] S. N. Pratiwi, C. Cari, N. S. Aminah, and H. Affandy, “Problem-Based Learning with Argumentation Skills to Improve Students’ Concept Understanding,” J. Phys. Conf. Ser., vol. 1155, no. 1, 2019.
[6] H. Affandy, N. S. Aminah, and A. Supriyanto, “Analisis Keterampilan Berpikir Kritis Siswa Pada Materi Fluida Dinamis Di SMA Batik 2 Surakarta,” J. Mater. dan Pembelajaran Fis., vol. 9, no. 1, pp. 25–33, 2019.
[7] C. Cari, P. S. Wulandari, N. S. Aminah, J. Handhika, and D. A. Nugraha, “Students’ understanding level of friction force direction concept on rolling object,” J. Phys. Conf. Ser., vol. 1153, no. 1, 2019.
[8] B. C. Madu, “Effect of the four-step learning cycle model on students’ understanding of concepts related to simple harmonic motion,” Asia-Pacific Forum Sci. Learn. Teach., vol. 13, no. 1, pp. 1–22, 2012.
[9] J. Alho, H. Silva, V. Teodoro, and G. Bonfait, “A simple pendulum studied with a low-cost wireless acquisition board,” Phys. Educ., vol. 54, no. 1, 2019.
[10] I. M. Candiasa, N. Santiyadnya, N. Sukajaya, and G. K. A. Sunu, “Contextualization of learning models in subak system for vocational education,” J. Phys. Conf. Ser., vol. 1165, no. 1, 2019.
[11] Cedefop, The changing nature and role of vocational education and training in Europe Volume 1: conceptions of vocational education and training: an analytical framework, vol. 2, no. No
63. 2017.

[12] L. R. Aiken, “Content validity and reliability of single items or questionnaires,” *Educ. Psychol. Meas.*, vol. 40, no. 4, pp. 955–959, 1980.

[13] A. L. R, “Three coefficients for analysing Reliability and Validity of rating,” *Educ. Psychol. Meas.*, vol. 45, pp. 131–142, 1985.

[14] M. R. Abraham, V. M. Williamson, and S. L. Westbrook, “A cross-age study of the understanding of five chemistry concepts,” *J. Res. Sci. Teach.*, vol. 31, no. 2, pp. 147–165, 1994.

[15] N. S. Aminah, *Assesmen Pembelajaran Fisika*, 1st ed. Surakarta: UNS Press, 2017.