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Student Response Analysis and Conception: Simple Harmonic Motion in High School

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Abstract

Each student has different abilities in understanding physics lessons because the concepts of physics are both constructive and abstract. This research was conducted to determine the level of understanding of students' concepts and the relationship between students' responses to the use of four tier instruments. The research method used is a mixed method with an exploratory design. The research subjects were students of class XI IPA SMAN Titian Teras H. Abdurrahman Sayoeti. The sampling technique is probability sampling. Data collection was carried out qualitatively and quantitatively using material expert validation sheets, four tier diagnostic tests and student response questionnaires. Qualitative data analysis techniques with assessment of material expert validation sheets and quantitative data with correlation test. The results of data processing obtained that the validator's assessment of the four tiers was 91.25% in the very good category, the correlation test was carried out between the questionnaire and the instrument, the significance result was 0.000 and the Pearson correlation was 0.753, which means it has a strong relationship and its use is responded well by students, the percentage is 97%.

Keywords: *Student Response; Instrument; Understanding Level*

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INTRODUCTION

Physics is a science that studies natural phenomena whose understanding is based on a mindset of knowledge, principles, concepts, theories and scientific laws that cover all parts of science (Mulia, 2019; Hendri & Faradhillah, 2020). Basically, physics concepts are constructs and abstracts that can be categorized in the form of non-verbal presentations (Hanna et al., 2016; Kaniawati, 2017). This form of presentation requires a good level of understanding in terms of both educators and students. However, in this case there is often a lack of good understanding from students because of difficulties in understanding and completing representations of different concepts (Pujayanto et al., 2018). These events will control students against conceptual errors slowly and continuously.

This misconception is often referred to as a misconception. Misconceptions are misunderstandings in interpreting concepts that are believed by experts (Ay, 2017; Mahfuzhoh, 2018;

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Harahap & Novita, 2020). This can happen because of differences in one's age, gender, ability, attitude and learning style (Silung et al., 2017; Sandora, 2018; Afidah & Mariati, 2019). So that it affects students' experiences and interactions with the environment, parents, peers and other media which can lead to conceptual deviations (Kurniasih & Haka, 2017; Wadana & Maison, 2019; Putra et al., 2019). Another factor is that students build wrong initial conceptions (Kusumaningrum et al., 2017; Suparno, 2013; Jannah & Rahmi, 2020) applied learning strategies and methods (Sholihat et al., 2017). These factors occur in almost all subjects and make the misconceptions experienced by students complex.

Misconceptions in natural science have been around for a long time and have been experienced by all levels of education (Howe, 1993; Thompson & Logue, 2006; Akbas & Gencturk, 2011; Zukhruf, 2018; Maison et al., 2019). Based on the research that has been done, it is obtained data that many physical materials experience misconceptions such as light and optical instruments (Widiyatmoko & Shimizu, 2018; Tumanggor et al., 2019), magnetism (Hermita et al., 2017), mechanics, thermodynamics, sound and waves, and modern physics (Suparno, 2013). The percentage of misconceptions of straight and parabolic motion is 45.8% (Fauziah & Darvina, 2019), the effect of gravity on object velocity 84% (Hasim & Ihsan, 2011), temperature and heat 29.52% (Nursyamsi et al., 2018), dynamic power 26% (Didik et al., 2020), momentum and impulse 14% (Hidayat et al., 2017), dynamic fluid 59% (Perdana & Rahardjo, 2018) and others.

One of the main subjects of physics studied at the high school level is simple harmonic motion. The concept is closely related to phenomena that occur in everyday life such as pendulum swings and springs. However, based on the results of previous studies, the material for simple harmonic motion experiences misconceptions in several sub-concepts. The sub-concepts are the direction and value of the restoring force, mass is proportional to frequency, velocity and acceleration (Khairunnisa et al., 2018) Determination of the value of the spring constant, graph of the period against mass (Mahen & Nuryanti, 2018), representation of mathematical equations, reading graphs and determining parameters in calculations (Adolphus et al., 2013; Sugara et al., 2016; Somroob & Wattanakasiwich, 2017). So we need a way to identify the misconceptions that occur in students.

Diagnostic tests are one of the ways that are currently widely used to diagnose, categorize and detect the causes of misconceptions and students' difficulties in learning. (Jubaedah et al., 2017; Dendodi et al., 2020). There are several types of diagnostic tests, namely one tier, two tier, three tier and four tier. One tier is a test that only has an answer selection level (Rusilowati, 2015). Two tier is a diagnostic test where at the first level students are directed to choose answers and the second level explains the answer choices (Noprianti & Utami, 2017; Efriani et al., 2019). Three tier is a test consisting of three levels with the first level of answer choices, the second reason for the answer and the third level of confidence (Syahrul & Setyarsih, 2015; Gurel et al., 2015).

Four tier is a test with the first level of choice of answers, the second is the belief in the answers, the third is the reason and the fourth is the level of confidence in the reasons (Yuberti et al., 2020). In its development to detect students' misconceptions on physics material, previous researchers have used a four-tier diagnostic test, but it is still relatively rare. This is because the four tiers are able to categorize students as understanding concepts, not understanding and misconceptions based on the level of belief (Fariyani et al., 2015; Sheftyawan et al., 2018; Leoni et al., 2020). As for the research that has implemented four tiers on physical materials such as light and optics (Rochim et al., 2019; Sheftyawan et al., 2018; Rawh et al., 2020), fluid concept (Diani et al., 2019), thermodynamics (Handayani et al., 2018), the concept of pressure and its application (Putri & Hasan Subekti, 2021), dynamic electricity (Ismail et al., 2015) and uniform circular motion (Annisa et al., 2019).

Based on the research conducted, the research questions are:

1. How is the feasibility of the four tier instrument to reveal students' misconceptions?
2. What is the category of students' level of understanding of the concept of simple harmonic motion?
3. How is the relationship between students' responses to the use of the four tier diagnostic test to identify the level of concept understanding?

METHODS

The method used in this study is a mixed method. Mixed method is a research method that collaborates qualitative and quantitative methods as well as data collection and analysis in one study

(Molina-Azorin, 2016; Molina-Azorin et al., 2018). This mixed method has three types of research methods, namely exploratory design, explanatory design and triangulation design. In this study, the researcher used an exploratory design. Exploratory design is to combine the presentation of qualitative and quantitative data where qualitative data is more dominant to explain the problem in more detail (Putra, 2017; Halcomb, 2019). This design model has three processes, namely the process of qualitative data, quantitative data and interpretation of the two data (Makhrus et al., 2018).

The subject of this research is class XI MIPA SMA N Titian Teras H. Abdurrahman Sayoeti. Population is a group of individuals with the same characteristics and criteria who are in the same environment at a certain time (Lesmana, 2021). The sample is part of the population that describes the characteristics of the population (Endra, 2017). The population in this study amounted to 110 students while the sample used was 86 students. The sampling technique in this study is probability sampling. Probability sampling is a data collection technique that provides an opportunity for each individual in the population to be selected as a sample (Borg et al., 1984; Sugiyono, 2016). To obtain the number of samples, the formula used is Nurdin et al (2018) as follows

$$S = \frac{N}{1 + Ne^2} \qquad (1)$$

where, N = Total population, e = significance level (5% or 1%).

There are two research data analysis, namely qualitative data obtained from material expert validation sheets while quantitative data, namely student response questionnaires and four-tier diagnostic test instruments in the form of multiple choice as many as 14 questions. The grid of the data collection instruments is presented in the table below. For the data collection instrument, the validator's assessment of the questions that will be distributed to students is in the form of a validation sheet, the following are some of the assessment indicators:

Table 1. Material Expert Validation Sheet Assessment indicators

No.	Assessment Indicator	Number of Questions
1	Material	5
2	Construction	7
3	Language	5
4	Instrument Display	1
	Total	18

Student response questionnaire is one of the quantitative data collection instruments distributed to students. This questionnaire has an assessment aspect which can be seen in table 2.

Table 2. Aspects of Student Response Questionnaire Assessment

No.	Aspects of Assessment	Quantity
1	Display questions for Four-Tier Diagnostic Test	2
2	Grammar and sentence structure	1
3	Fill	3
4	Processing time for four-tier diagnostic test questions	1
	Total	7

In addition, there is a diagnostic test question in the form of four multiple choice tiers on simple harmonic motion material. The concepts tested in the test are as follows:

Table 3. Simple Harmonic Motion Question Indicator

No.	Concept Indicator Question	Quantity
1	Vibration on spring	3
2	Pendulum Vibration	2
3	Position, angular frequency, velocity and acceleration	6
4	Potential Energy, kinetic energy and mechanical energy	3
	Total	14

There are two data analysis techniques in this study, namely qualitative data with instrument feasibility tests from validator assessments before being distributed to students using the following formula Mardiah et al (2018):

$$P = \frac{\sum x}{max\ score} \times 100\% \qquad (2)$$

with P = total percentage

$\sum x$ = validator assessment score.

The number of assessment questions in the material expert validation sheet is 18 questions using a 5-level Likert scale, namely as follows:

Table 4. Rating with a 5-Level Likert Scale

Value	Score Range	Category
5	81-100	Very Good
4	61-80	Good
3	41-60	Not Good
2	21-40	Not Good
1	0-20	Very Not Good

(Zulmiyetri et al., 2019)

For quantitative data analysis techniques in research using descriptive and inferential statistics. The first descriptive statistic is to categorize students' misconceptions based on the following table:

Table 5. Category Level of Student Concept Understanding

Tier 1	Tier 2	Tier 3	Tier 4	Decision
True	Sure	True	Sure	Scientific Conception
True	Sure	True	Not Sure	Lack of Knowledge
True	Not Sure	True	Sure	Lack of Knowledge
True	Not Sure	True	Not Sure	Lack of Knowledge
True	Sure	False	Sure	False Positive
True	Sure	False	Not Sure	Lack of Knowledge
True	Not Sure	False	Sure	Lack of Knowledge
True	Not Sure	False	Not Sure	Lack of Knowledge
False	Sure	True	Sure	False Negative
False	Sure	True	Not Sure	Lack of Knowledge
False	Not Sure	True	Sure	Lack of Knowledge
False	Not Sure	True	Not Sure	Lack of Knowledge
False	Sure	False	Sure	Misconception
False	Sure	False	Not Sure	Lack of Knowledge
False	Not Sure	False	Sure	Lack of Knowledge
False	Not Sure	False	Not Sure	Lack of Knowledge

(Kaltakci, 2012)

Second, calculate the mean and mode of students in each category and concept that has misconceptions.

Third, calculate the percentage of each category that has been obtained using the formula Suwarna (2013) following:

$$P = \frac{f}{N} \times 100\% \qquad (3)$$

With P = percentage of categorical group

f = the number of students in each category group

N = total number of students in the study

Fourth, identify misconceptions and classify the percentage level of understanding according to the following percentages:

Table 6. Category Percentage Level of Concept Understanding

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

(Istighfarin et al., 2015)

Fifth, calculating student responses to the use of the four tier diagnostic test instrument with a Likert scale used is a four category Likert scale, namely as follows:

Table 7. Categories of Student Response Percentage

Value	Range RS (%)	Category
4	$81 \leq \%RS < 100$	Very Good
3	$62 \leq \%RS < 81$	Good
2	$43 \leq \%RS < 62$	Not Good
1	$25 \leq \%RS < 43$	Very Not Good

Sixth, using inferential statistics by testing the relationship between student responses to the use of the four-tier instrument to identify the misconceptions experienced. The calculation uses the Pearson product moment correlation test using IBM SPSS Statistics 25. The decision-making requirements for the two variables show the relationship if sig $< 0{,}05$ then the two variables have a relationship but if the value of sig $> 0{,}05$ then the two variables have no relationship (Purwanto, 2018; Rahmatih et al., 2020). The results of the two correlations of the two variables can be seen based on the following table:

Table 8. Degree of Correlation

Correlation Value	Correlation Category
0,81 – 1,00	Over Power
0,61 – 0,80	Power
0,41 – 0,61	Medium
0,21 – 0,40	Weak
0,00 – 0,20	Very Weak

(Rahmatih et al., 2020)

The stages of research carried out by researchers can be seen in the following chart::

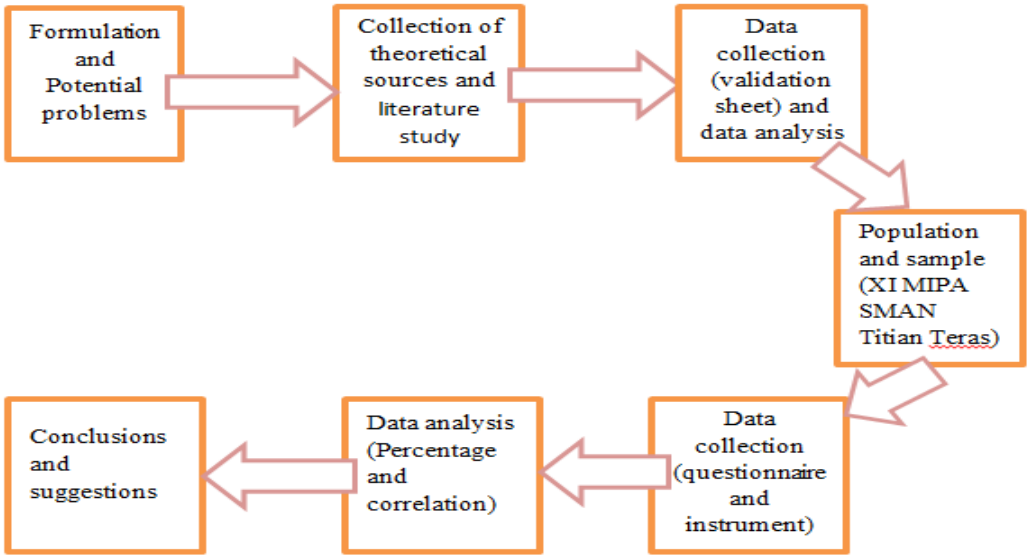

Figure 1. Research Flow

RESULTS & DISCUSSION

Results

The four tier diagnostic test in this study was used to find out the misconceptions experienced by students. However, the test is first tested for feasibility by the validator. The validator in this case is a material expert lecturer as many as 3 people. From the validator's assessment, the following results were obtained*:*

Table 9. Validator Assessment Results

No.	Rating Indicator	V1	V2	V3	Mean	Category
1	Material	95%	96%	100%	97%	Very Good
2	Construction	86%	89%	89%	88%	Very Good
3	Language	100%	100%	100%	100%	Very Good
4	Instrument display	80%	80%	80%	80%	Good
	Total average				91,25%	Very Good

From the table 9, it can be seen that the average value of the percentage of material, construction and language is included in the very good category, while the instrument display is in good category. The total average of the validator's assessment of the four tier diagnostic test questions is 91.25%, including in the very good category. Therefore, the instrument is feasible to use to identify students' misconceptions. Based on the distribution of questions that are declared feasible to be used, the results of the categorization of the level of understanding of students' concepts on simple harmonic motion material are obtained.

There are five categories for the level of understanding of students' concepts, namely first, SC (scientific) which means that students' concepts are the same as scientific concepts. The percentage results can be seen in the following table:

Table 10. Result of Scientific Concept Category

Category	Sub concept	N	P (%)	Mean	Modus	Criteria
Scientific	Vibration on spring	27	31	24,25%	N = 25 (29%)	Medium
	Pendulum Vibration	10	11			Low
	Position, angular frequency, velocity and acceleration	22	26			Low
	Potential Energy, kinetic energy and mechanical energy	25	29			Low

From the table above, it can be seen that the average percentage of students who have a conception in accordance with the scientific conception is 24.25% and the subconcepts that get the highest percentage are potential, kinetic and mechanical energy.

The second is the FP (false positive) category where students are wrong in choosing the level of reason but are sure of the reason. The percentage results for these categories are as follows:

Table 11. Result of False Positive Category

Category	Sub concept	N	P (%)	Mean	Modus	Criteria
False Positive	Vibration on spring	18	21	22,5%	N = 21 (24%)	Low
	Pendulum Vibration	20	23			Low
	Position, angular frequency, velocity and acceleration	19	22			Low
	Potential Energy, kinetic energy and mechanical energy	21	24			Low

From the table 11, it can be seen that the average percentage of students in the false positive category is 22.25% and the sub-concepts that get the highest percentage are potential, kinetic and mechanical energy.

The third is the FP category (false negative) where students are wrong in choosing the level of answer choices but are sure of their choices. The percentage results for these categories are as follows:

Table 12. Result Category False Negative

Category	Sub concept	N	P (%)	Mean	Modus	Criteria
	Vibration on spring	3	4			Low
False	Pendulum Vibration	7	8	4,25%	N = 7	Low
Positive	Position, angular frequency, velocity and acceleration	3	4		(8%)	Low
	Potential energy, kinetic energy and mechanical energy	1	1			Low

From the table 12, it can be seen that the average percentage of students who are in the wrong negative category is 4.25% and the sub-concepts that get the highest percentage of motion on the pendulum.

The fourth is the MSC (misconception) category where students are wrong in choosing the level of answer choices and reasons but are sure of the choice of answers and reasons chosen. The results of the percentage category of misconceptions are as follows:

Table 13. Results Category Misconception

Category	Sub conception	N	P (%)	Mean	Modus	Criteria
	Vibration on spring	18	20		N = 29	Low
Misconception	Pendulum Vibration	29	33	26,25%	(33%)	Low
	Position, angular frequency, velocity and acceleration	19	22			Low
	Potential energy, kinetic energy and mechanical energy	26	30			Low

From the table 13, it can be seen that the average percentage of students who experience misconceptions is 26.25% and the sub-concept that gets the highest percentage is pendulum movement.

The fifth is the LK (Lack of Knowledge) category, which means that students lack knowledge of the concept. This can happen if students choose all the appropriate levels listed in table 2.5. The results of the percentage of the category of lack of knowledge are as follows:

Table 14. Result of Lack of Knowledge Category

Category	Sub concept	N	P (%)	Mean	Modus	Criteria
Lack of	Vibration on spring	20	23			Low
Knowledge	Pendulum Vibration	22	25	23,75%	N = 23	low
	Position, angular frequency, velocity and acceleration	20	23		(25%)	Low
	Potential energy, kinetic energy and mechanical energy	21	24			Low

From the table 14, it can be seen that the average percentage of students who experience lack of knowledge is 23, 75% and the sub-concepts that get the highest percentage are position, frequency, speed and acceleration.

After knowing the category of the level of understanding of the concept of the students, then the data testing carried out was a student response questionnaire to the use of the four tier diagnostic test instrument, the following results were obtained:

Table 15. Percentage of Questionnaire Results Student Response

No.	Aspects of Assessment	%	Category
1	Display questions for Four-Tier Diagnostic Test	97	Very Good
2	Grammar and sentence structure	98	Very Good
3	Fill	97	Very Good
4	Processing time for four-tier diagnostic test questions	97	Very Good
	Average	97	Very Good

The results of the calculation of the percentage of student responses to the use of the four tier diagnostic test were obtained by 97% in the very good category, which means that students responded that the instrument was useful for identifying misconceptions.

The next data processing is to test the correlation of student responses to the use of the four tier diagnostic test using IBM Statistic SPSS 16 to see the relationship between the two with the following results:

Table 16. Correlation Results of Student Responses and Instruments

		Respon	Fourtier
Respon	Pearson Correlation	1	.753**
	Sig. (2-tailed)		.000
	N	86	86
Foutier	Pearson Correlation	.753**	1
	Sig. (2-tailed)	.000	
	N	86	86

**. Correlation is significant at the 0.01 level (2-tailed).

Discussion

Four tier diagnostic test is a diagnostic test that has two types of confidence levels, namely the level of student confidence in choosing answers and reasons. The instrument used in this research was first assessed and corrected by the three validators contained in question 7, the image contained in the question was not clear and the spring position was not appropriate. For item 11, the source of shooting is not listed. In addition, in the instructions for working on the questions, the time to work on the questions should be mentioned because this is a test to identify students' misconceptions. Therefore, the researchers made improvements to the instrument.

The corrected questions were distributed to 86 students of class XI MIPA at SMAN Titian Teras via Google Form. The results obtained show that the category of students' conceptual understanding level is classified as medium and low which is listed in table 3.2 to table 3.6. The category that has the highest percentage value is misconception of 26% and the highest misconception is in the sub-concept of pendulum vibrations. Where, students assume that the change in the value of the spring period is directly proportional to the mass value, the speed of the pendulum moving is not affected by the value of gravity where the clock is placed and temperature affects the speed of the pendulum.

Students' misconceptions cannot be avoided, as evidenced by the results of the research. If the misconception continues, it will have a bad influence on all parties. As a result, to accept the next conception will have a difficult impact because you are already used to the previous concept (Yuliati, 2017). Another impact of misconceptions is the decline in student learning outcomes which can be seen from the results of the learning evaluation (Lestari, 2019; Alfionitari et al., 2019). Therefore, students' misconceptions need to be identified.

The importance of knowing the level of student understanding is not only for educators but also for students themselves. This can be seen from the students' responses to the four tier instrument with an average percentage gain of 97% in the very good category. The relationship between the two variables was tested with IBM Statistic SPSS 16, the result was sig 0.000< 0.05 dan the result of the pearson

correlation is 0.753 with a strong correlation category. This means that the two variables have a strong relationship. So that the four tier instrument was accepted by students based on the appearance, content, language, material being tested and the processing time.

The four tier diagnostic test instrument is useful, as a learning evaluation tool to find out the possible difficulties of students in the material that has been taught (Rusilowati, 2015). The test is also used to determine the level of understanding of the concepts possessed (Dendodi et al., 2020). The instrument proved to be useful in simple harmonic motion material to identify misconceptions and categorize the level of understanding of students' conceptions. The purpose of the test is to make students try to learn according to scientific conceptions to improve their learning outcomes.

CONCLUSION

Based on the research that has been done, it can be concluded that the four-tier instrument used to identify student misconceptions is valid and feasible to use with a percentage value of 91.25% in the very good category. Identification of the category level of understanding of students' concepts that there are 24% of students have scientific concepts, 22% of students are wrongly positive, 4% are wrongly negative, 26% have misconceptions and 23% lack knowledge. The highest percentage of concept understanding category is the misconception contained in the pendulum period sub-concept. The existence of student responses is to determine student responses to the use of four tier instruments as an evaluation tool to identify misconceptions and categorize students' conceptual understanding. The sig value of the two variables is 0.000 and the correlation value is 0.753, meaning that it has a strong relationship.

In this case, this instrument can be used by educators to see students' conceptual understanding to determine remediation techniques and students can improve their learning styles. This instrument can also be linked to students' interest and motivation in learning.

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