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Developing MOFI on Transverse Wave to Explore Students' Misconceptions Today: Utilizing Rasch Model Analysis

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Abstract: This research aimed to describe the diagnostic instrument validity from Multi-representation of Four-tier Instrument on Transverse Wave (MOFI-OTW), which is useful in exploring the misconceptions. The ADDIE (Analyzing, Designing, Developing, Implementing, and Evaluating) model has already been utilized as the research method. In the developing stage, item construction is in the form of multi-representation (statements, pictures, graphs, tables, and mathematical symbols). The sample consisted of 81 high school students aged 16-18 years (23 males called *"Cung"* and 58 females called *"Nduk")* in East Java. Data validity, instrument reliability, and distribution of students' conceptions have been analyzed using the Rasch Model with MINISTEP 4.7.0.0 software. Validity based on item dimensionality is valid. The reliability based on Cronbach Alpha (α) is good category, the value of item reliability is very good category, and person reliability is moderat category. Students' conceptions are categorized as Sound Understanding (SU), Partial Understanding Positive (PUP), Partial Understanding Negative (PUN), No Understanding (NU), Misconception (MC), and No Coding (NC). The largest conception category is MC. Misconceptions are still found in the sub-concept of transverse wave in various representations. In conclusion, MOFI-OTW can be developed through the ADDIE model by utilizing the Rasch analysis and used to explore students' conceptions and misconceptions.

Keywords: MOFI; Four Tier Instrument; Transverse Wave; Misconception; Rasch Model Analysis

Introduction

The concept of physics is a basic thing that must be possessed by high school students (Ozkan & Selcuk, 2015; Samsudin et al., 2021; Suprapto et al., 2017) because physics is a science that is widely applied in everyday life. During learning activities at school students have gained concepts related to the material being studied. However, students often find conceptions that are not in accordance with scientific conceptions. In this case, it is called misconception (Kaniawati et al., 2019).

Misconceptions are caused by several factors such as intuitive thinking, phenomena seen, book texts, learning media, or activities during learning (Suprapto, 2020). Misconceptions can be seen as a conception or cognitive structure that is firmly attached to the minds of students, which actually deviates from the conceptions put forward by scientists (Suhandi et al., 2020). In this situation, the conceptions held by students contradict the conceptions of physics scientists.

This is in line with several findings which say that there are still many students who experience misconceptions about physics topics (Gurel et al, 2015). Waves are the basic material that must be studied to understand advanced fields such as optics, electromagnetic waves, and quantum mechanics (Xie et al, 2021). One of the concept studies on mechanical waves is transverse waves. An important sub-concept in transverse waves is the speed of propagation of transverse waves in ropes (Barniol & Zavala, 2016; Goodhew et al., 2019; Caleon & Subramaniam, 2013; Caleon & Subramaniam, 2010; Tongchai, et al., 2011). However, based on the facts in the field, in this sub-concept, students are confused about things that can

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affect the speed of wave propagation on a rope. Most high school students are stuck with the following two mathematical equations.

$$v = \lambda . f \quad (1)$$

and

$$v = \sqrt{\frac{F}{\mu}} \quad (2)$$

Based on equations 1 and 2, many students misunderstood the concepts related to the things that affect the speed of the waves in the rope. The impact of misconceptions that are still attached to students will affect the concepts studied further (Perdana et al., 2018).

In exploring students' conceptions related to the speed of propagation of transverse waves on ropes, various methods can be used, namely through interviews, concept maps, open-ended tests, and multiple-choice tests (Gurel et al., 2015). Multiple choice tests, as the method used to diagnose misconceptions, which has many advantages, namely they can directly know students' conceptions and effective (Gierl et al., 2017).

Several studies have developed multiple-choice tests in the form of two-tier instruments (Lengkong et al., 2021), three-tier (Taslidere, 2016; Gurcay & Gulbas, 2015; Caleon & Subramaniam, 2010), and four-tier (Kaltakci-Gurel et al., 2017; Kaniawati, et al., 2019; Laliyo et al., 2021). The four-tier diagnostic instrument is the latest development after two-tier and three-tier instruments. The four-tier instrument added confidence levels at tier two and four. This level of confidence makes it perfect for diagnosing students' misconceptions. Based on the advantages of this four-tier instrument with a multiple-choice format, in this research, a diagnostic instrument was developed about the speed of transverse wave propagation on rope.

However, several studies in developing diagnostic tests at the tier-1 are only in the form of pictures and statements, whereas in physics itself other representations such as graphical representations, tables, and mathematical symbols need to be prioritized as well. Learning the concept of transverse wave itself inevitably requires all representations, students may experience misconceptions from some of these representations when studying waves. The presentation of a four-tier diagnostic instrument with multi-representation construction was only started by Fratiwi et al. (2020) and Samsudin et al. (2020). This means that four-tier diagnostic instruments with multi-representation construction are still few found. Therefore, in this research, a four-tier diagnostic instrument was developed by presenting questions in the form of multi-representation so that it was called the Multi-representation of Four-tier Instrument on Transverse Wave (MOFI-OTW).

Research conducted by Barniol & Zavala (2016), Goodhew et al. (2019), Caleon & Subramaniam (2010), Tongchai et al. (2011), Aykutlu et al. (2021), Tumanggor et al. (2020), and Xie, et al. (2021) analysis of misconceptions about transverse waves on a rope is done manually. In developing the MOFI-OTW and exploring students' conceptions for this research using the Rasch model analysis. Rasch measures have been used as a tool for assessing diversity in education, school psychology, and many other fields (Boone & Noltemeyer, 2017). Sumintono (2018) revealed that the Rasch model can be used by educators to develop test items and provide information related to the assessment and distribution of students' conceptions. In addition, Rasch analysis can be used to assess the measurement function of the instrument (Boone, 2016).

In physics education, Rasch model analysis has been carried out in many research to diagnose misconceptions such as Aminudin et al. (2019), Fratiwi et al. (2020), Samsudin, et al. (2020), Adimayuda et al. (2020), and Laliyo, et al. (2021). However, Rasch analysis of diagnostic instruments dealing with transverse wave is rarely performed. Therefore, this research aimed to develop a Multi-representation of Four-tier Instrument on Transverse Wave (MOFI-OTW) and to explore students' misconceptions through the analysis of the Rasch Model.

Method

We have developed a diagnostic instrument that is used to identify and explore students' misconceptions. The ADDIE (Analyzing, Designing, Developing, Implementing, Evaluating) model is used as a method in this research, which is presented in Figuer 1.

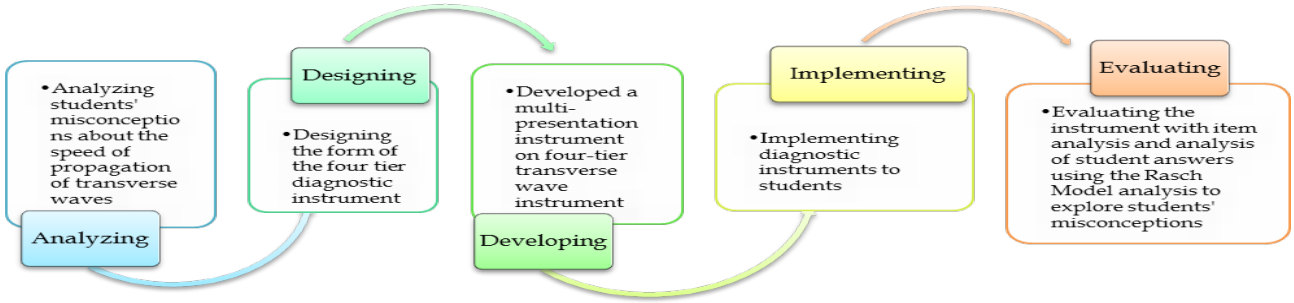

Figure 1. Research design is using ADDIE

Participants

The sample of this research consisted of 81 high school students aged 16-18 years (23 males called "Cung" and 58 females called "Nduk") in Tuban, East Java, Indonesia. All samples that have received transverse wave material are selected by cluster random sampling. Tuban Regency is located on the northern coast of Java, which is 101 km from the capital city of East Java (Surabaya). The map of the district of Tuban, East Java is shown in Figure 2.

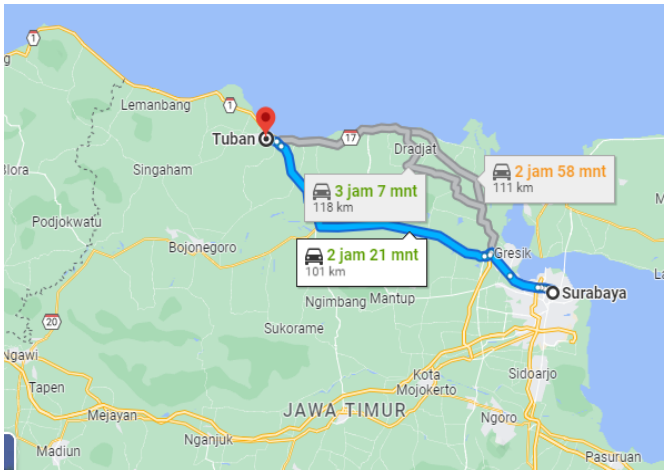

Figure 2. Map of Tuban Regency from Surabaya

Instruments

The instrument used is Multi-representation of Four-tier Instrument on Transverse Wave (MOFI-OTW), which consists of seven items. MOFI-OTW consists of the sub-topic of the speed of transverse waves on a rope. The multiple representations presented in the items consist of representations of statements, pictures, graphs, tables, and mathematical symbols.

Data Analysis

The development of the MOFI-OTW was analyzed using the Rasch MINISTEP 4.7.0.0 software model based on the validity results of item dimensionality, Cronbach alpha, item reliability, and person reliability. The instrument is said to be valid by reviewing the results of item dimensionality, namely 1) the value of the raw variance explained by measures is more than 20%, and 2) the value of the explained variance in 1st contrast is less than 3 for the eigenvalues and less than 15 for the observed values (Adams, Sumintono et al, 2018 and Fisher, 2007). Reliability of the question in terms of the value of Cronbach alpha, item reliability, and person reliability. Each is interpreted in Table 1 and Table 2.

Table 1. Interpretation of Reliability Test based on Cronbach Alpha Value (α)

Cronbach Alpha Value	Interpretation
α <0.5	Very Bad
0.5 ≤ α < 0.6	Bad
0.6≤ α < 0.7	Moderate
0.7≤ α < 0.8	Good
0.8≤ α	Very Good

Source: (Sumintono & Widhiarso, 2014)

Table 2. Interpretation of Item Reliability and Person Reliability Values

Value of Item Reliability and Person Reliability	Interpretation
Value <0.67	Weak
0.67< Value<0.8	Moderate
0.8< Value < 0.9	Good
0.9< Value < 0.94	Very Good
0.9< Value	Special

Source: (Sumintono & Widhiarso, 2015)

The exploration of students' misconceptions was analyzed from the results of the Wright maps. Student conceptions and scoring were adapted from Aminudin, et al (2019), which are shown in Table 3.

Table 3. Categories of Students' Conceptions

Tier	Categories of Students' Conception																
	SU	PUP										PUN			NU	MC	NC
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1 (Option)	C	C	C	C	C	C	C	C	IC	IC	IC	IC	IC	IC	IC	IC	IA
2 (Level Confidence)	S	S	NS	NS	S	S	NS	NS	S	S	NS	NS	S	NS	NS	S	
3 (Reason)	C	C	C	C	IC	IC	IC	IC	C	C	C	C	IC	IC	IC	IC	
4 (Level Confidence)	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS	NS	S	NS	S	

Descpription: Sound Understanding (SU), Partial Understanding Positive (PUP), Partial Understanding Negative (PUN), No Understanding (NC), Misconception (MC), and No Coding (NC). Correct (C), Incorret (IC), Sure (S), Not Sure (NS), and Incomplete Answer (IA)

Scores of students' conceptions and misconceptions are shown in the Table 4.

Table 4. Conception and misconception score

Category	Score	
	Conception	Misconception
Sound Understanding (SU)	4	0
Partial Understanding Positive (PUP)	3	0
Partial Understanding Negative (PUN)	1	1
No Understanding (NC)	0	3
Misconception (MC)	0	4
No Coding (NC)	(empty)	(empty)

Result and Discussion

Analyzing

This stage analyzes students' misconceptions based on previous research. The literature study was carried out to adjust the material received by students at school. The concept under review is the speed of wave propagation. In addition, an analysis of preliminary studies was carried out in schools in Tuban, East Java, Indonesia. The questions used are in the form of two-tier as shown in Figure 3. In tier-1 it is in the form of multiple choice, while tier-2 is in the form of open-ended.

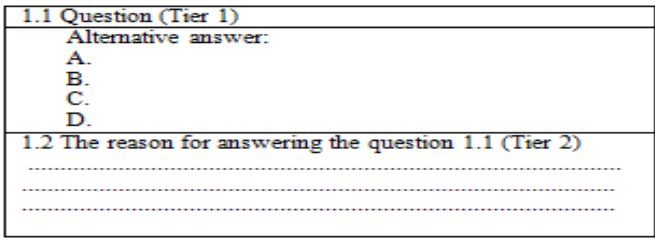

Figure 3. Two-tier diagnostic instrument form

The results of preliminary studies provide information that students have not been able to give scientific reasons correctly. The concept of students is not complete. In fact, there are still many students who experience misconceptions or alternative conceptions based on students' intuition.

Designing

The instrument is designed in the form of a four-tier diagnostic instrument. The form of the four-tier diagnostic instrument is a transformation from the previous two-tier diagnostic instrument. The design form of this four-tier diagnostic instrument is presented in Figure 4. The first tier is a multiple choice test, the third tier is a closed-ended answer (namely multiple choice), and the second and fourth tiers are the level of confidence. The reasoning options at tier-3 were obtained from students' answers at tier-2 when using a two-tier diagnostic test. Student answers were coded for multiple choice on tier-3 of the four-tier diagnostic instrument. This instrument is useful for exploring students' concepts and misconceptions.

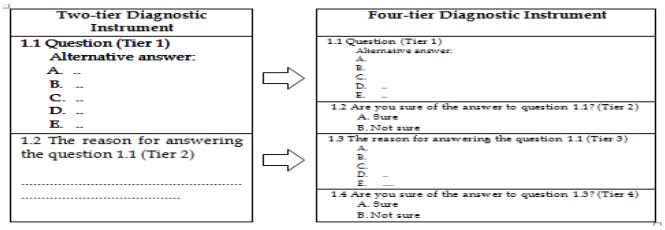

Figure 4. Transformation of MOFI-OTW from two-tier to four-tier

Developing

In this stage, instrument development is carried out to complete the lack of instruments in previous research and the results of preliminary studies. The instruments that have been made in previous research are only in the form of statements and pictures. Moreover, in the concept of fast transverse wave propagation on a rope, many are presented in the form of pictures, graphs, and mathematical equations. Following this need, the development of a variety of questions is not only made in the form of statement representation, but also in the form of multi-representations.

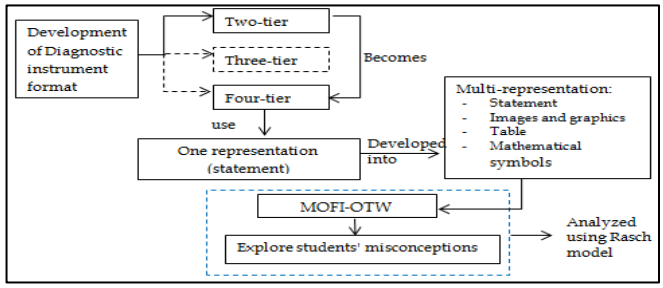

Figure 5. Flow of MOFI-OTW development

An example of a item from MOFI-OTW is presented in Figure 6.

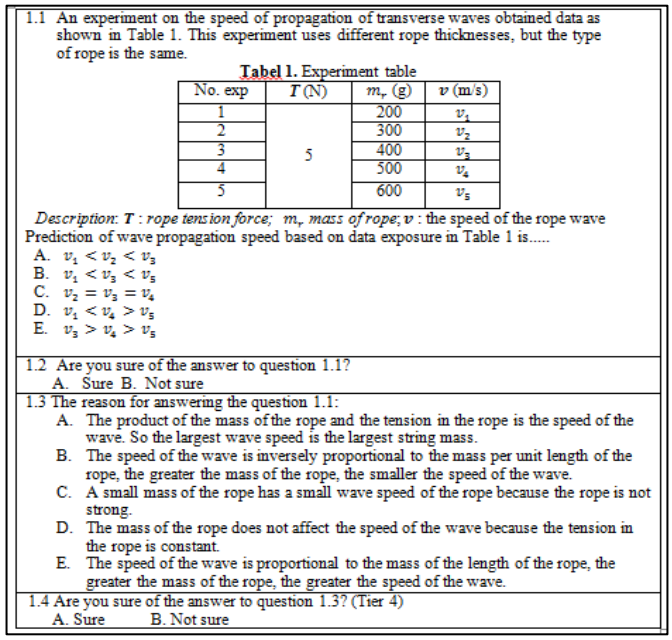

Figure 6. The example of MOFI-OTW

Implementing

During the implementation, MOFI-OTW was distributed to several school locations in Tuban, East Java, Indonesia. The instrument is given as many as seven items via google-form, as shown in Figure 7.

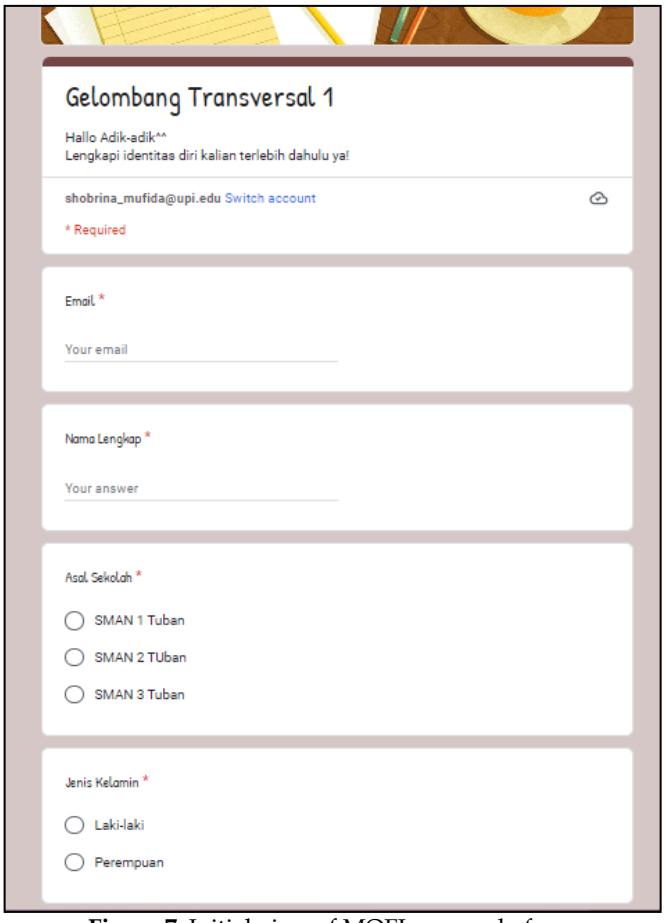

Figure 7. Initial view of MOFI on google-form

Evaluating

The evaluation stage is the last. Before exploring students' misconceptions, an analysis of the items was carried out based on validity (item dimensionality), Cronbach alpha, item reliability, and person reliability. Analysis of the item test using the Rasch model with MINISTEP 4.7.0.0 software. The results of the validity and reliability of the questions are explained as follows.

```
    Table of STANDARDIZED RESIDUAL variance in Eigenvalue units = Item information units
                                        Eigenvalue   Observed   Expected
Total raw variance in observations   =      20.5914 100.0%        100.0%
  Raw variance explained by measures =      13.5914  66.0%         64.2%
    Raw variance explained by persons =       2.7664  13.4%         13.1%
    Raw Variance explained by items   =      10.8250  52.6%         51.1%
  Raw unexplained variance (total)    =       7.0000  34.0% 100.0%  35.8%
    Unexplned variance in 1st contrast =      1.6406   8.0%  23.4%
    Unexplned variance in 2nd contrast =      1.4813   7.2%  21.2%
    Unexplned variance in 3rd contrast =      1.1915   5.8%  17.0%
    Unexplned variance in 4th contrast =      1.1370   5.5%  16.2%
    Unexplned variance in 5th contrast =       .8331   4.0%  11.9%
```

Figure 8. Validity Results of MOFI-OTW

Figure 8 shows the value of the raw variance explained by measures is 66%. According to Sumintono (Sumintono & Widhiarso, 2015), the value of raw variance is explained by measures if more than 60% is said to be very appropriate. In addition, the expalained variance in 1st contrast eigenvalue is 1.64 (less than 3) and the observed value is 8% (less than 15%). Based on these results, it means that MOFI-OTW is a valid instrument. The values of Cronbach alpha, item reliability, and person reliability are presented in Figure 9.

```
|          TOTAL                          MODEL          INFIT        OUTFIT    |
|          SCORE     COUNT     MEASURE    S.E.      MNSQ   ZSTD   MNSQ   ZSTD |
|-------------------------------------------------------------------------------|
| MEAN       9.8       7.0        -.81     .47                                  |
|  SEM        .7        .0         .14     .03                                  |
| P.SD       5.6        .0        1.19     .28                                  |
| S.SD       5.7        .0        1.20     .28                                  |
| MAX.      28.0       7.0        4.32    1.89                                  |
| MIN.       .0        7.0       -4.22     .34                                  |
|-------------------------------------------------------------------------------|
| REAL RMSE    .59 TRUE SD    1.03  SEPARATION  1.76  Person RELIABILITY  .76   |
|MODEL RMSE    .55 TRUE SD    1.06  SEPARATION  1.93  Person RELIABILITY  .79   |
| S.E. OF Person MEAN = .14                                                     |
-------------------------------------------------------------------------------
Person RAW SCORE-TO-MEASURE CORRELATION = .94
CRONBACH ALPHA (KR-20) Person RAW SCORE "TEST" RELIABILITY = .71  SEM = 3.06
STANDARDIZED (50 ITEM) RELIABILITY = .96

    SUMMARY OF 7 MEASURED (NON-EXTREME) Item
-------------------------------------------------------------------------------
|          TOTAL                          MODEL          INFIT        OUTFIT    |
|          SCORE     COUNT     MEASURE    S.E.      MNSQ   ZSTD   MNSQ   ZSTD |
|-------------------------------------------------------------------------------|
| MEAN     105.1      75.0         .00     .19      1.09   -.15   1.37    .57 |
|  SEM      29.4        .0         .59     .07       .20    .68    .32    .75 |
| P.SD      72.0        .0        1.44     .17       .48   1.66    .78   1.84 |
| S.SD      77.7        .0        1.55     .18       .52   1.80    .84   1.99 |
| MAX.     220.0      75.0        2.97     .60      2.21   3.16   2.92   3.96 |
| MIN.      11.0      75.0       -1.62     .10       .68  -2.38    .48  -1.72 |
|-------------------------------------------------------------------------------|
| REAL RMSE    .27 TRUE SD    1.41  SEPARATION  5.17  Item   RELIABILITY  .94   |
|MODEL RMSE    .26 TRUE SD    1.41  SEPARATION  5.53  Item   RELIABILITY  .95   |
| S.E. OF Item MEAN = .59                                                       |
-------------------------------------------------------------------------------
Item RAW SCORE-TO-MEASURE CORRELATION = -.90
```

Figure 9. The results of Cronbach alpha, item reliability, and person reliability of MOFI-OTW

The Cronbach Alpha value is obtained from the relationship between item reliability and person reliability. Figure 9 shows the Cronbach Alpha (α) value is 0.71, so it is categorized as "Good". The results of the item reliability items are 0.94 and 0.95, where the instrument belongs to the "Very good" category. In addition, the results of person reliability are 0.76 and 0.79, which are included in the "Moderate" category. The Multi-representation of Four-tier Instrument (MOFI) on Transverse Wave is a steady instrument. That is, the instrument developed can measure what should be measured.

Based on the results of this research, we have developed a diagnostic instrument that is used to identify and explore students' misconceptions. This diagnostic instrument called MOFI-OTW, which has been developed through the ADDIE model (Analyzing, Designing, Developing, Implementing, Evaluating). Analysing of the Rasch Model in Figure 8, it can be concluded that MOFI-OTW is valid to use. This is by Adams et al. (2018) and Fisher (2007) research that the instrument has a unidimensionality quantity which is

good when the value of the raw variance explained by the observed measure is above the mean of 40%, and the value of the explained variance in 1st contrast is less than 3 for the eigenvalues and less than 15 for the observed values.

A good instrument is not only valid but must be reliable as well. In Figure 9, the values for item reliability and person reliability are 0.94 and 0.76. So the Cronbach Alpha value is 0.71. According to Sumintono & Widhiarso (2015), the Cronbach Alpha value is a good instrument. Score item reliability and person reliability from 0 to close to 1 can be interpreted as a more consistent measurement (Boone & Noltemeyer, 2017). MOFI-OTW is a valid and reliable diagnostic instrument for 7 items. So Multi-representation of Four-tier Instrument on Transverse Wave (MOFI-OTW) is a valid and reliable diagnostic instrument to use.

Furthermore, in exploring students' misconceptions, starting by categorizing students' conceptions into the categories of Sound Understanding (SU), Partial Understanding Positive (PUP), Partial Understanding Negative (PUN), No Understanding (NU), Misconception (MC), and No Coding (NC). Overall the percentage results from each category of student conception are shown in Figure 10.

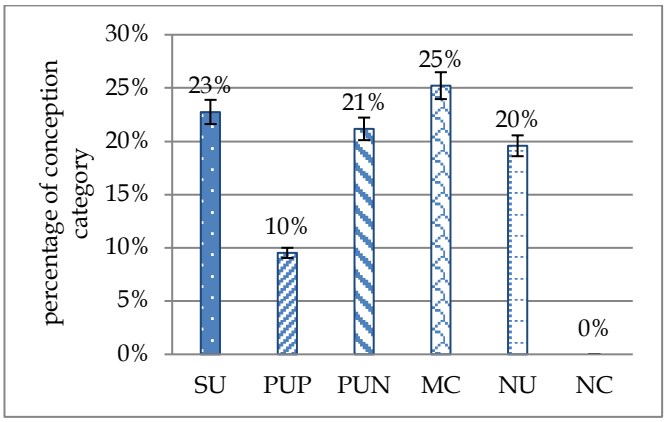

Figure 10. Percentage of each category of student conception on transversal wave

The percentage results show that students who have categories in SU are 23%, PUP is 10%, PUN is 21%, MC is 25%, NU is 20%, and NC is 0%. This finding shows that misconceptions still occur in students after students get material on the speed of transverse waves at school. This can be seen in Figure 10, the MC category occupies the largest percentage among others.

Exploration of students' misconceptions is reviewed based on the results of students' distributions on the Wright maps in Figure 11. Based on Figure 11 (a), on the right is the distribution of questions, namely Q1, Q2, Q3, Q4, Q5, Q6, and Q7 (7 questions). The left side is the distribution of students coded with numbers along with the gender of male (*Cung*/C) and female (*Nduk*/N). Reviewing the results of the conception mapping presented in Figure 11(a), the number Q3 is the most difficult question, while the number Q4 is the easiest question.

In Figure 11(a), students who have the most potential to have scientific conceptions are students with codes 01N, 38N, 08N, 33N, 27C, 66N, and 41N. Students coded 01N and 38N are students who have the most scientific conceptions because these two students can answer all the questions correctly. This finding was caused by the fact that the two students were above the logit of the most difficult questions (Q3). Meanwhile, students who tend not to have concepts or have more potential for misconceptions are students coded 70N, 72N, 73N, 74N, 68C, 69N, 12C, 62C, 43N, 45N, 64C, 47N, 48N, 49N, 55N, 56C, 57C, 58N. , 59C, 61C, and 67N.

The results of the distribution students' misconceptions in Figure 11(b) are the opposite of the results of the concept mapping in Figure 11(a).

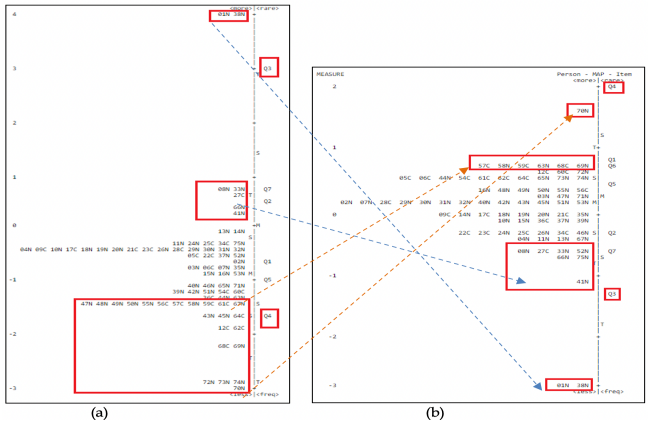

Figure 11.Distribution of students based on Wright map results; Figure.11(a). Distribution of students' conceptions, Figure 11(b). Distribution of students' misconceptions

The results of the misconception mapping using the Wright map are useful for exploring students' misconceptions in more detail. The students with the highest potential for misconceptions were students with codes 70N, 57C, 58N, 59C, 63N, 68C, and 69N. This is the following Figure 11(a), the student is at the bottom. In addition, students who experienced the least potensial misconceptions were students coded 41N, 66N, 75N, 52N, 33N, 27C, and 08N, even students coded 01N and 38N did not experience misconceptions because they could answer the most difficult questions (all correct answers).

Looking at the exploration of students' misconceptions in detail from the Wright maps in Figure 11(a), only 01N and 38N (female students) could answer all the questions correctly. While 24 students are said to have low concepts and 12 students have the potential to experience misconceptions that are more vulnerable. Based on Figure 11(b), a total of three male students

(57C, 59C, and 68C) and four female students (70N, 58N, 63N, and 69N) had the greatest potential to experience misconceptions.

Examples of student conceptions for the categories of Sound Understanding (SU), Partial Understanding Positive (PUP), Partial Understanding Negative (PUN), Misconception (MC), and No Understanding (NU) are described in Table 5.

Table 5. The Example of Student Conception

Conception Category	Example of Students' Conception
Sound Understanding (SU)	01N can answer questions Q1. 01N selects the option that the greater the mass of the rope, the smaller the value of the wave speed because the mass per unit length of the rope is inversely proportional to the speed of the wave. In addition, 01N is said to have understood the concept, in which case 01N chose the correct mathematical symbol option. Student 01N believes in the tier-1 answer and the tier-3 reason. So it is said that 01N has the SU category.
Partial Understanding Positive (PUP)	27C can answer question Q2. 27C states that when the tension in the rope and the mass per unit length of the rope are fixed, the frequency does not affect the speed of the tension in the rope. However, 27C is not sure about the tier-1 answer and the tier-3 reason. So it is said that 27C has the PUP category.
Partial Understanding Negative (PUN)	32N can only choose the tier-1 answer option by selecting the appropriate mathematical symbol from question Q1. However, 32N could not help but choose scientific reasoning for tier-3. 32 N states that which says that the speed of the wave is not affected by the mass of the rope because the tension force and the length of the rope are kept constant. In addition, 32N is not sure about the tier-1 answers and the tier-3 reasons. So 32N is identified as having the PUN category.
Misconception (MC)	70N has had a misconception of the sub-concepts in Q2. 70N thought that as the frequency increased, the wave propagation speed also increased, even though the tension in the string and the mass per unit length of the string were kept constant. The reason given is because the frequency changes more and more based on the equation $v = \lambda.f$. In addition, 70N believes in tier-1 answers and tier 3 reasons. So 70N is categorized as MC.
No Understanding (NU)	62C cannot answer Q1. 62C selects the option of a mathematical equation that shows the greater the mass of the string, the greater the speed of the wave. 62C was not sure on tier-1 but sure on tier-3. Therefore, 62 students are categorized as NU.

In Table 5, it is explained that the misconceptions that occur are related to the sub-concepts of the relationship between the tension force of the rope, the mass per unit length of the rope, the velocity of the wave in the rope, and the relationship between the frequency, the wavelength, and the speed of the waves on the rope. This finding can be said that there are still many students who experience misconceptions in interpreting the concept of transverse waves in various forms of representation. The concept that students have is less than excellent because students who do not understand the form of representation do not understand certain concepts (Sutopo, 2016). This is in sequence with the research of Fratiwi, et al. (2020), misconceptions occur when students read graphs. Misconceptions are caused by students not studying concepts in-depth. Often students only memorize formulas without understanding the physical meaning of the formula (Goodhew, et al., 2019).

Based on this result and discussion, teachers can use the Multi-representation of Four-tier Instrument on Transverse Wave (MOFI-OTW) to explore and identify students' misconceptions about the concept of transverse wave both before and after learning activities. In addition, the teacher must also take further learning actions for students who are still experiencing misconceptions. Learning activities can be carried out through strategies, approaches, or learning models that include cognitive conflict activities and the development of teaching materials such as worksheets, learning media, and modules containing conceptual change theory. Other research can be carried out in different areas and with larger samples.

Conclusion

This research concluded that the Multi-representation of the Four-tier Instrument on Transverse Wave (MOFI-OTW) can be developed through the ADDIE model. The diagnostic instrument was developed in a multi-representation form. The results of the Rasch Model analysis for validity from item dimensionality were valid and reliable from item reliability values of 0.94 in the very good category, person reliability of 0.76 in the moderate category, and Cronbach Alpha value of 0.71 in the good category. MOFI-OTW was a valid and reliable instrument to explore students' misconceptions about the sub-concept of transverse wave propagation speed. Moreover, there are still many students in the category of misconception (MC) and No Understanding (NU) about the sub-concepts of the relationship between tension in a rope, mass per unit length of a rope, and the speed of propagation of transverse waves in a rope.

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