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Development of a multitier open-ended work and energy instrument (MOWEI) using Rasch analysis to identify students' misconceptions

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Abstract

This research aims to the development of a Multitier Open-ended Work and Energy Instrument (MOWEI) using Rasch analysis and identifies students' misconceptions. This research method uses the 4D model (Defining, Designing, Developing, and Disseminating). The research participants involved were 30 Javanese students from XI class (12 male students called "*Mas*" and 18 female students called "*Mba*"), the average age was 16 years old. The development of a close-ended four-tier instrument is based on the students' answers to MOWEI. The analysis results obtained that MOWEI is a valid and reliable instrument to identify misconceptions. The results of the identification of misconceptions in participants found that the highest misconceptions occurred at number 10 that was 73% and the lowest misconceptions of 10% occurred at numbers 4 and 11.

Keywords: Multitier Open-ended Work and Energy Instrument (MOWEI), Rasch analysis, Javanese students' misconceptions

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1. Introduction

Assessment of student learning outcomes is important. With the implementation of the assessment, the teacher can find out the learning outcomes, student learning progress, student conception, and can evaluate the learning process. Assessment can be done by measuring the learning outcomes of students (Alkharusi & Al-Hosni, 2015; Caspersen et al., 2017; Ogunleye & Anyaegbuna, 2018; Shrader PharmD et al., 2017). To be able to take measurements requires a measuring instrument. One of them is a diagnostic test instrument. The multitier instrument is a type of diagnostic test instrument in the form of multiple-choice (Aminudin et al., 2019; Purwanto et al., 2020; Versteeg et al., 2019). The instrument can be used to measure students' conceptions, conceptual change, alternative conceptions, and misconceptions (Nuzulira Janeusse Fratiwi, Samsudin, Ramalis, Saregar, et al., 2020; Hadinugrahaningsih et al., 2020; Ozkan & Selcuk, 2015). This is important because the discussion of alternative conceptions or misconceptions is included in popular research in physics education (Nuzulira Janeusse Fratiwi, Samsudin, Ramalis, & Costu, 2020). Besides, the multitier instruments contain questions and level of confidence. Multitier instruments have been developed in various instrument formats such as the two-tier format (Chen et al., 2003) three-tier format (Kirbulut & Geban, 2014), and the four-tier format (Gurel et al., 2015). The Multitier Open-ended Work and Energy Instrument (MOWEI) is a four-tier format diagnostic test instrument to identify students' misconceptions on Work and Energy concept.

Four-tier diagnostic test instruments can be used well to evaluate alternative conceptions (Afif et al., 2017; N. J. Fratiwi et al., 2019; Hermita et al., 2017) and are more accurate in diagnosing misconceptions (Nuzulira Janeusse Fratiwi et al., 2017; Kaltakci-Gurel et al., 2017). On the four-tier test instrument, the first tier and the third tier are questions with multiple-choice options, the second tier and the fourth tier are questions of the level of confidence of students' answers. By using a four-tier multitier instrument, we can find out the students' conception of the Work and Energy concept. In addition, we can find out the level of confidence of students in answering questions. In MOWEI, the third tier is open-ended questions, no answer choices are provided so students can fill in based on their own conceptions. Then, students' answers in the third tier will be used to develop MOWEI into a four-tier close-ended diagnostic test instrument using Rasch model.

The Rasch model is modelling for analysing data. The Rasch model was designed by Georg Rasch to construct test instruments using the item and person parameter (Boone, W. J. & Noltemeyer, 2017; Rasch, 1960; Suryana et al., 2020). The Rasch model provides psychometric analysis techniques that can be used by teachers to develop item tests questions and important tools that can provide information related to student assessment for learning (Habibi et al., 2019; Ng et al., 2018; Sumintono, 2018). Boone, W. J. & Noltemeyer (2017) also revealed that Rasch's analysis technique can facilitate the development of instruments. Analysis of the development of instruments using Rasch model began widely used in physics education. The advantage of the Rasch model is that it allows researchers to obtain elaborate and more comprehensive results (Suryana et al., 2020). Based on the literature, physics instruments that have been developed using Rasch's analysis are Multitier Open-ended Momentum And Impulse (MOMI) (Adimayuda et al., 2020); Static Fluid Concept Inventory (SFCI) (Purwanto et al., 2020); Multitier Open-ended Light-Wave Instrument (MOLWI) (Aminudin et al., 2019); Static Fluid Four-Tier Instrument (SFFTI) (Septiantini et al., 2020); Multitier of Greenhouse Effect (MoGE) (Kania et al., 2020); Multi representation of Tier Instruments on Newton's law (MOTION) (Samsudin et al., 2020). However, the development of instruments relating to the Work and Energy concept has not yet been found using Rasch model. Meanwhile, the concept often misconceptions occur. Thus, the development of instruments on Work and Energy concepts such as MOWEI needs to be done in order to identify students' misconceptions.

As an initial step to overcome misconceptions, it is necessary to immediately identify first (Maharani et al., 2019). There are several ways that can be used to identify misconceptions, including diagnostic tests, structured assignments, giving open questions, analysing each step of students' answers, and interviews (Erman, 2017; Fariyani et al., 2017; Kolomuc et al., 2012). Researchers use diagnostic test instruments because they can test their level of understanding efficiently (Adimayuda et al., 2020; Downing, 2015). MOWEI is a diagnostic test instrument used by researchers to identify misconceptions on the Work and Energy concept by Javanese students.

Indonesia is a country famous for various races, cultures, and tribes from Sabang to Merauke. The five biggest ethnic groups are Javanese, Sundanese, Malay, Batak, and Madurese (Ananta et al., 2013). Javanese are the largest ethnic group in Indonesia. In Javanese, men are called "*Mas*", and women are called "*Mba*". Thus, Javanese is an interesting thing to discuss, because, in several places, there are still many misconceptions about the concept of work and energy (Brna, 1988; Ermawati et al., 2019; Gilbert & Watts, 1983; Kubsch et al., 2017; Liu & Fang, 2016). In this case, the researcher aims to conduct research to find out the Javanese students' misconceptions about Work and Energy concept.

This research aims to develop instruments and identify students' misconceptions on the Work and Energy concept using Rasch analysis. Students' answers on MOWEI will be analysed using the Rasch model, assisted using the Ministep 3.75.0 software. This analysis is used to determine the quality of the instrument seen from the instrument validity, item validity, item and person reliability, and the level of difficulty obtained from the output tables menu. Based on the description above, in Figure 1 explains the research flow, which underlies the research.

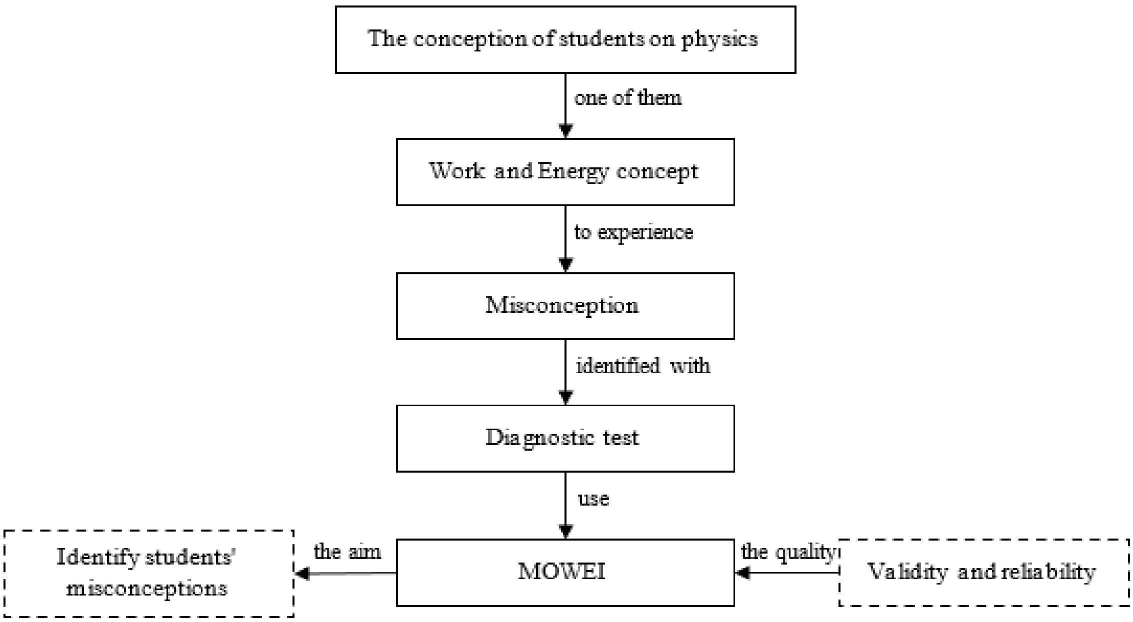

Figure 1. Research flows

Figure 1 shows the research flow carried out. The instrument developed will pass the stages of validity and reliability to determine its quality. Thus, we hope that MOWEI can be used as an instrument to identify misconceptions about work and energy concepts.

2. Research Method

2.1. Research Model

This research uses a 4D model consisting of four stages, namely defining, designing, developing, and disseminating. In the defining stage, the authors search for literature from books and articles to find out the concepts that occur misconceptions by students on the Work and Energy concept. In the designing stage, the authors make the MOWEI based on the study of students' misconceptions of literature. In the developing stage, the aims to develop MOWEI into a four-tier close-ended instrument. The last stage is disseminating, the instruments that have been made are implemented for students and then analysed using Rasch analysis. The 4D research flow is explained in Figure 2.

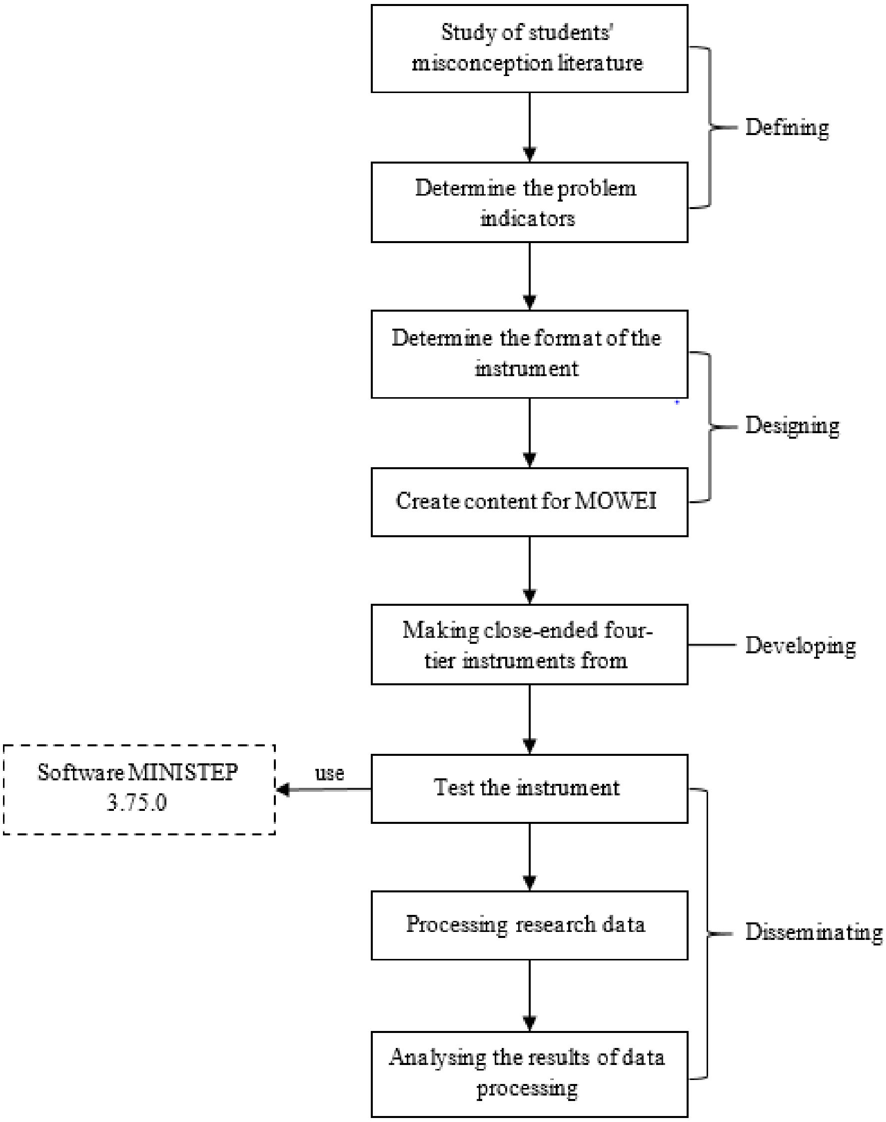

Figure 2. The 4D research flow

2.2. Participant

This study involved 30 class XI students' in Kebumen City. Kebumen is a district in Central Java Province and one of the places where Javanese students come from. On the map, the city of Kebumen can be seen in Figure 3.

Figure 3. The map of Kebumen city (Source by Google Maps)

Figure 3 shows a map of Kebumen based on the Central Java region. Cultural diversity, discussion, and social make each region has its own characteristics. One of them is in mentioning calls to male students called “*Mas*” and female students called "*Mba*". In this study involving 12 students "*Mas*" and 18 students “*Mba*” with an average age of 16 years.

2.3. Instrument

The instruments in this study use the Multitier Open-ended Work and Energy Instrument or the so-called MOWEI. The MOWEI is a four-tier open-ended diagnostic test instrument to identify students' misconceptions on Work and Energy material. The first tier contains questions about the concept of Work and Energy, the second tier is the level of confidence in the answers in the first tier, the third tier contains the question of the reason for the answer in the first tier, and the fourth tier is a question of the level of confidence in the answer to the third tier. The MOWEI contains concepts of positive work and negative effort, the law of conservation of mechanical energy, the theorem of Work and Energy, and work by conservative forces and work by non-conservative forces.

2.4. Data analysis

Data analysis is divided into two parts, namely the development of instruments and identification of misconceptions, as follows:

2.4.1. Development of instruments

This analysis aims to determine the quality of instruments as seen from the validity of the instrument, the validity of items, the reliability of items and person, and the level of difficulty assisted by using MINISTEP software 3.75.0. Previously the students' answers were coded into the students' conception categories based on Table 1 (Aminudin et al., 2019). Then scoring using scores of misconceptions based on Table 2. We choose to use misconception scores because he wanted to know the quality of instruments in measuring students' misconceptions. This scoring was adopted from research conducted (Kaltakci-Gurel et al., 2017). Sound Understanding (SU) is given a score of '0' because students can answer correctly in the first tier, third tier, and are confident in the level of confidence. Partial Positive (PP) will get a score of '0' due to students answering correctly on the first tier and third tier, but they are still unsure of one level of confidence. Partial Negative (PN) is given a score of '1' because students can answer correctly on the first tier or third tier. Not understanding (NU) was given a score of '3', students could not answer correctly in the first tier and fourth tier. For those who answered incorrectly on the first tier and third-tier but have a certain level of confidence in the answer, it is called Misconception (MC) and is given the highest score of '4'. Then, No Coding (NC) is not given a score because students do not answer in one or more tiers.

Table 1. Student conception category

Tier	Category																
	SU		PU					PN					MC		NU		NC
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	C	C	C	C	C	C	C	C	I	I	I	I	I	I	I	I	IA
2	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS	S	S	NS	NS	
3	C	C	C	C	I	I	I	I	C	C	C	C	I	I	I	I	
4	S	S	NS	NS	S	S	NS	NS	S	S	NS	NS	S	NS	S	NS	

Note: SU: Sound Understanding, PP: Partial Positive, PN: Partial Negative, MC: Misconception, NU: No Understanding, NC: No Coding, C: True, I: False, S: Confident, NS: Not sure, IA: Incomplete answer

Table 2. Score of misconception

Conception category	SU	PU	PN	MC	NU	NC
Score	0	0	1	3	4	-

2.4.2. Identification of students' misconceptions

This analysis aims to identify students' misconceptions about the Work and Energy concept. The identification of students' misconceptions is analysed based on the responses of students. The responses of students' responses are then categorized into six categories of conceptions. The conception category includes Sound Understanding (SU), Partial Positive (PP), Partial Negative (PN), Misconception (MC), No Understanding (NU), and No Coding (NC) (Adimayuda et al., 2020; Aminudin et al., 2019; Purwanto et al., 2020). Then, a percentage was made on the Misconception (MC) category for each item and each submitter.

3. Results and Discuss

This section is the result of research conducted. The results obtained will be presented based on the 4D research design (Defining, Designing, Developing, and Disseminating).

3.1. Defining

At the defining stage, we have conducted a literature study on misconceptions that students have on the Work and Energy concept. We collect references from research and physics books that can be trusted. Then the authors determine the indicators of competency achievement based on basic competencies or KD of 3.9 contained in the 2016 high school physics syllabus in Indonesia. In creating instrument content, the writer combines misconceptions held by students with indicators of competency achievement.

3.2. Designing

After collecting references, at the designing stage, the authors make MOWEI with a format like a Figure 4a MOWEI is an instrument consisting of four tiers. The first tier is a multiple-choice question with five answer choices. Second-tier and fourth-tier contain the level of confidence in the answers to the first tier and third tier. The third tier is the reason for the answer to the answer in the first tier in the form of an open question. Students fill the reason for the answer in the third tier with their own conceptions. It aims to identify students' conceptions on the Work and Energy concept. For the form of a four-tier close-ended instrument of Work and Energy such as MOWEI. It's just that, the choice of answers in the third tier four-tier close-ended Effort and Energy in the form of multiple choices. The four-tier close-ended instrument format can be seen in Figure 4b.

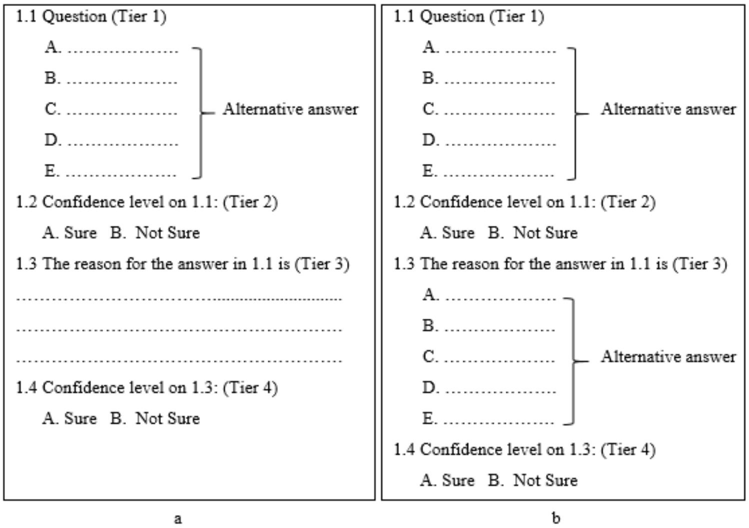

Figure 4. Four-tier: a) open-ended format; b) close-ended format

3.3. Developing

At the developing stage, we are developing a four-tier open-ended instrument into a four-tier close-ended instrument. The open-ended instrument contains 14 items called MOWEI. At this stage, the authors fill in the third-tier answer choices for the four-tier close-ended instrument based on the conception of students in the third tier MOWEI. An example of the MOWEI is shown in Figure 5.

10.1 There is a patient with Covid-19 who is about to be moved from the second floor to an ambulance on the first floor. There are three paths that can be used to move the patient. How the ratio of the work done by gravity on the Covid-19 sufferer on the path if friction is ignored?

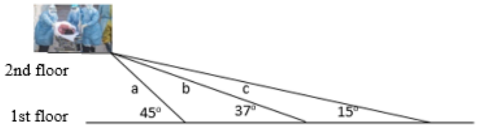

Figure 8. Path of transfer of the patient

A. The wok in the lane *a* is greater than the wok in lane *b*
B. The wok in the lane c is greater than the wok in lane *a*
C. The wok in the lane *c* is greater than the wok in lane *b*
D. The wok in the lane *a* is smaller than the wok in lane *b*
E. The work on all lanes is the same

10.2 Are you sure about answer on 10.1?

A. Sure B. Not Sure

10.3 The reason you answered answer choice 10.1 is

....
....
....

10.4 Are you sure about reason on 10.3?

A. Sure B. Not Sure

Figure 5. The example of MOWEI

Then, the conception of students in the third tier MOWEI is used to fill in the choice of reasons for the third-tier answer for the four-tier close-ended instrument. One example of a four-tier close-ended as the development of MOWEI as shown in Figure 6.

10.1 There is a patient with Covid-19 who is about to be moved from the second floor to an ambulance on the first floor. There are three paths that can be used to move the patient. How the ratio of the work done by gravity on the Covid-19 sufferer on the path if friction is ignored?

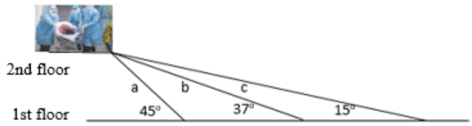

Figure 8. Path of transfer of the patient

A. The wok in the lane *a* is greater than the wok in lane *b*
B. The wok in the lane c is greater than the wok in lane *a*
C. The wok in the lane *c* is greater than the wok in lane *b*
D. The wok in the lane *a* is smaller than the wok in lane *b*
E. The work on all lanes is the same

10.2 Are you sure about answer on 10.1?

A. Sure B. Not Sure

10.3 The reason you answered answer choice 10.1 is

A. The tilt angle affects the work done
B. The path taken is shorter
C. The path taken is closer to the first floor
D. The path taken is steeper
E. The work is done by a conservative force

10.4 Are you sure about reason on 10.3?

A. Sure B. Not Sure

Figure 6. The example of a four-tier close-ended

3.4. Disseminating

At this stage, the instrument is tested on students. The conception data of students who have been collected is processed using MINISTEP 3.75.0 software then analysed using Rasch model and identification of misconceptions.

3.4.1. Instrument analysis

This analysis aims to measure the quality of the instrument. Reliability through MINISTEP 3.75.0 software is obtained with the 3.1 Summary Statistics output menu shown in Figure 7. The results show person reliability is 0.58 and 0.63, item reliability is 0.89 and 0.90. Person reliability values indicate the reliability of students into the category of "Weak" and the reliability items indicate the reliability of the instruments included in the "Good" category. The reliability of the interaction between person reliability and item reliability is described by Cronbach alpha (KR-20). Cronbach alpha (KR-20) has a value of 0.60, this value falls into the "Fair" category. The reliability results show that MOWEI is reliable.

```
INPUT: 30 Person  14 Item  REPORTED: 30 Person  14 Item  5 CATS  MINISTEP 3.75.0
--------------------------------------------------------------------------------

  SUMMARY OF 30 MEASURED Person

-------------------------------------------------------------------------------
|     TOTAL                 MODEL        INFIT       OUTFIT   |
|     SCORE    COUNT   MEASURE   ERROR      MNSQ   ZSTD   MNSQ   ZSTD |
|-----------------------------------------------------------------------------|
| MEAN     28.0     14.0       .00    .20      1.01     .0   1.04     .0 |
| S.D.      8.5       .0      .32    .02       .36    1.1    .63    1.0 |
| MAX.     44.0     14.0       .62    .24      2.34    3.7   3.70    3.8 |
| MIN.     12.0     14.0     -.66    .19       .48   -2.0    .45   -1.5 |
|-----------------------------------------------------------------------------|
| REAL RMSE   .21 TRUE SD   .25  SEPARATION  1.17  Person RELIABILITY  .58 |
|MODEL RMSE   .20 TRUE SD   .26  SEPARATION  1.31  Person RELIABILITY  .63 |
| S.E. OF Person MEAN = .06                                                   |
-------------------------------------------------------------------------------
Person RAW SCORE-TO-MEASURE CORRELATION = 1.00
CRONBACH ALPHA (KR-20) Person RAW SCORE "TEST" RELIABILITY = .60

  SUMMARY OF 14 MEASURED Item
-------------------------------------------------------------------------------
|     TOTAL                 MODEL        INFIT       OUTFIT   |
|     SCORE    COUNT   MEASURE   ERROR      MNSQ   ZSTD   MNSQ   ZSTD |
|-----------------------------------------------------------------------------|
| MEAN     60.0     30.0       .00    .14      1.00     .0   1.04     .1 |
| S.D.     25.5       .0      .45    .03       .26    1.2    .44    1.3 |
| MAX.    107.0     30.0       .67    .22      1.54    1.7   2.08    3.1 |
| MIN.     22.0     30.0     -.96    .12       .53   -2.8    .45   -2.3 |
|-----------------------------------------------------------------------------|
| REAL RMSE   .15 TRUE SD   .42  SEPARATION  2.87  Item  RELIABILITY  .89 |
|MODEL RMSE   .14 TRUE SD   .43  SEPARATION  3.03  Item  RELIABILITY  .90 |
| S.E. OF Item MEAN = .12                                                     |
-------------------------------------------------------------------------------
```

Figure 7. The reliability of MOWEI

The validity of the instrument using MINISTEP software 3.75.0 is obtained from the output menu of table 23. Item: Dimensionality is shown in Figure 8. The minimum limit for instrument validity is 20%. In the validity of MOWEI, the measurement value of raw variance is 37.6%. The value of the validity of the instrument is more than 20% as the study of (Septiantini et al., 2020). Therefore, MOWEI can be said to be a valid instrument.

```
INPUT: 30 Person  14 Item  REPORTED: 30 Person  14 Item  5 CATS  MINISTEP 3.75.0
--------------------------------------------------------------------------------

   Table of STANDARDIZED RESIDUAL variance (in Eigenvalue units)
                                         -- Empirical --    Modeled
Total raw variance in observations     =     22.4 100.0%          100.0%
 Raw variance explained by measures    =      8.4  37.6%           37.6%
  Raw variance explained by persons    =      3.9  17.2%           17.2%
  Raw Variance explained by items      =      4.6  20.4%           20.4%
 Raw unexplained variance (total)      =     14.0  62.4% 100.0%    62.4%
  Unexplned variance in 1st contrast   =      2.8  12.4%  19.8%
  Unexplned variance in 2nd contrast   =      2.1   9.6%  15.3%
  Unexplned variance in 3rd contrast   =      1.8   8.2%  13.1%
  Unexplned variance in 4th contrast   =      1.4   6.1%   9.8%
  Unexplned variance in 5th contrast   =      1.3   5.6%   9.0%
```

Figure 8. The validity of MOWEI

These results are obtained from data processing using MINISTEP software 3.75.0 on the output menu item (column) output: fit orders. Item fit explains whether the item is functioning well or not to take measurements. Based on Table 3, 9 items meet the three criteria of the three categories of item suitability. For 5 other items 4 items, namely numbers 5, 9, 10, and 13, still fulfil one of the three categories, so that it does not need to be replaced. However, at number 11 does not meet the three categories of item suitability, this is because the MNSQ and ZSTD values exceed the maximum limits (1.5 and 2) and the PT Mean Corr value is outside the received range (0.4 <PT Mean Corr <0.85). Thus, it can be concluded, as many as 13 items are valid and one item number 11 needs to be replaced or eliminated.

Table 3. The analysis of MOWEI validity

Question	Score MNSQ	Score ZSTD	Score PT Mean Corr	The result of MNSQ ZSTD	The result of PT Mean Corr
Q1	0.69	-0.9	0.55	Received	Very good
Q2	0.86	-0.6	0.50	Received	Very good
Q3	1.17	0.7	0.42	Received	Very good
Q4	0.45	-2.3	0.55	Received	Very good
Q5	0.95	0.1	0.31	Received	Good
Q6	1.02	0.2	0.41	Received	Very good
Q7	0.87	-0.6	0.52	Received	Very good
Q8	0.75	-1.1	0.60	Received	Very good
Q9	1.04	0.2	0.36	Received	Good
Q10	2.00	2.0	0.17	Received	Not good
Q11	2.08	3.10	0.01	Rejected	Not good
Q12	1.06	0.4	0.49	Received	Very good
Q13	0.98	0.1	0.19	Received	Not good
Q14	0.69	-0.6	0.56	Received	Very good

In addition to the analysis, the level of difficulty can also be used to see the quality of the instrument. From the measure items obtained the standard deviation (SD) value of 0.45. SD value is combined with the average logit grade point average to classify the difficulty of item questions. Researchers use misconception scores in processing data so that the level of difficulty items are sorted by items with the most correct answers of students. Can be analysed based on the value of 0.0 logit + 1SD is a group of easy questions; greater than + 1SD is a very easy matter; 0.0 logit -1SD is a difficult problem; and smaller than -1SD is a very difficult problem, adaptation from (Sumintono, 2018). Based on the elaboration, there are four categories of difficulty levels, namely very difficult, difficult, easy, and very easy. From Table 4 it can be seen that the level of difficulty is distributed into four categories (Very difficult, Difficult, Easy, and Very easy). This shows the level of difficulty of the MOWEI items which are well distributed.

Table 4. The analysis of MOWEI validity

Question	Measure	The level of difficulty
Q1	0.44	Easy
Q2	0.16	Easy
Q3	0.30	Easy
Q4	0.36	Easy
Q5	-0.96	Very difficult
Q6	0.67	Very easy
Q7	0.05	Easy
Q8	0.19	Easy
Q9	-0.12	Difficult
Q10	-0.53	Difficult
Q11	0.31	Easy
Q12	0.15	Easy
Q13	-0.37	Difficult
Q14	-0.65	Difficult

Another analysis of the level of difficulty using the misconception score can be shown by the right-hand side of the line in Figure 9.

```
INPUT: 30 Person  14 Item  REPORTED: 30
---------------------------------------

MEASURE    Person - MAP - Item
              <more>|<rare>
  1                 +
                    |
                    |T
                    |
                    |
                   T|  Q6
               00L  |
               16P  |
               02L  |S Q1
                    |
     11P  20L  28P S|  Q11   Q4
               21L  |  Q3
          04L  10P  |  Q8
     01P  03L  29L  |  Q12   Q2
     09P  15L  22L  |  Q7
  0  05P  18P  25P M+M
     19P  24P  26P  |
          12P  30P  |  Q9
               07P  |
                    |
               13L S|  Q13
               17P  |
               06P  |S
                    |  Q10
               27L  |
          14L  23P T|  Q14
                    |
                    |
                    |T
                    |  Q5
 -1                 +
              <less>|<frequent>
```

Figure 9. Difficulty level distribution

Question number Q6 is a very easy question because it is located at the top of other questions. While Q5 number questions are at the bottom which means they are very difficult. From Figure 9 it can be seen that the degree of difficulty is well spread. In addition, Figure 9 shows the potential misconceptions of students in the Work and Energy material using MOWEI. 00L students (*Mas* or male) show the highest potential for misconception. Meanwhile, students 14L and 23P (*Mba* or female) have the lowest potential for misconception.

3.4.2. Identification of students' misconceptions

Identification of students' misconceptions was obtained from a preliminary study using the MOWEI instrument that was applied to 30 Javanese students. The results of students' answers are presented according to their conception category shown in Figure 10.

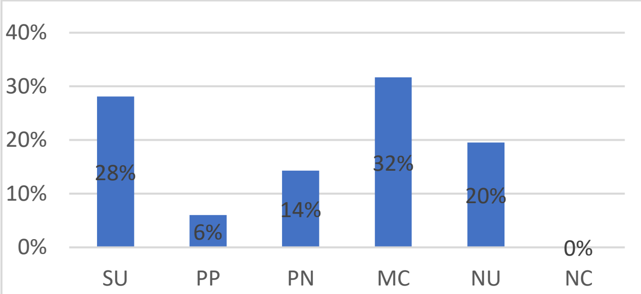

Figure 10. Percentage of students' conceptions

The percentage for each category is in the Sound Understanding (SU) category by 28%, the Partial Positive (PP) category by 6%, the Partial Negative (PN) category by 14%, the Misconception category as a percentage of 32%, the Not Understanding (NU) category occurred by 20% and the category No Coding (NC) did not occur in all students 0%. The highest percentage occurred in the Misconception (MC) category, while the lowest percentage occurred in the No Coding (NC) category. This indicates that the conception of students who are misconceptions is still a problem in learning Physics. These results are in line with research conducted (N J Fratiwi et al., 2019) found the highest conception of students occurred in alternative conceptions. While, the percentage of students' misconceptions on each item is shown in Figure 11.

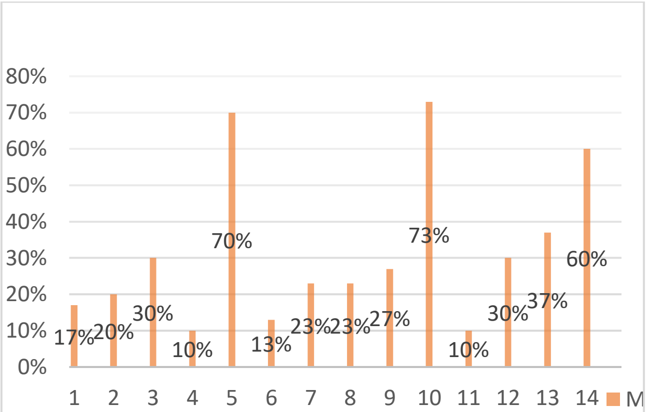

Figure 11. Percentage of students' misconceptions

From Figure 11 it can be seen that the highest misconception occurs at number 10 which is 73% and the lowest misconception of 10% occurs in numbers 4 and 11. For example in number 10 that is about an object which moves from a height through three different passes. Many students answer that if the object uses the shortest path then the effort made by the earth is the smallest. Javanese students consider the work done by the conservative style one of which is the gravity is influenced by the length of the trajectory travelled. In addition, Table 5 explains the frequency and percentage of students' misconceptions in each concept in Work and Energy concept.

Table 5. Recapitulation of students' misconceptions using MOWEI

No	Concept	Item	The frequency of students' misconceptions	%
1.	Positive and negative wok	Q1	5	17
		Q2	6	20

No	Concept	Item	The frequency of students' misconceptions	%
2.	The law of mechanical energy conservation	Q6	4	13
		Q7	7	23
		Q8	7	23
		Q14	18	60
3.	Theorem of work and energy	Q3	9	30
		Q4	3	10
		Q11	3	10
		Q12	9	30
3.	Work by a conservative and non-conservative force	Q5	21	70
		Q9	8	27
		Q10	22	73
		Q13	11	37

The highest percentage of students is in item Q5, the concept of "Work by a conservative and non-conservative force" of 70%. Meanwhile, the smallest percentage of students is in items Q4 and Q11, the concept of "Theorem of work and energy" of 10%. That is because the concept of work by a conservative and non-conservative force often occurs concept swaps, so that makes students sometimes answer work by conservative, which should be work by non-conservative. Meanwhile, students better understand the concept of the theorem of work and energy because this form is easier in terms of concepts.

4. Conclusion

MOWEI is a valid and reliable instrument to identify students' misconceptions about the Work and Energy concept. The results of the identification of conceptions in students show that Javanese students still experience misconceptions about the Work and Energy concept. The results were obtained based on the results of tests of the instruments tested on 30 Javanese students.

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