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Development of Google Form-Based Five-Tier E-Diagnostic Test to Identify Conception Levels and Track Students' Misconceptions on Thermodynamics Materials

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Abstract

The learning process can not be separated from the assessment activities. Google form is one of the assessment applications used during Covid-19 pandemic. In learning physics, students often have difficulty understanding concepts, leading to misconceptions. Student interview results showed that thermodynamics is a complex material. This research aims to develop a five-tier diagnostic test based on google form to identify the conception levels and track misconceptions in thermodynamic material. Research & Development method with eight stages, namely potential and problems, information gathering, instrument design, design validation, design revision, trial, instrument revision, and research test, was applied to obtain the instrument. The feasibility of the test was met by the results of validity and reliability tests. A total of 12 questions were successfully developed and declared valid and reliable at the value of 0.601. The research sample consisted of 47 students of 11th Grade of MAN 1 Bojonegoro. The results showed that the google form-based five-tier e-diagnostic test developed was able to identify conception levels and track students' misconceptions on thermodynamic material. The highest conception levels were dominated by Lack of Knowledge and the presence of misconceptions reached 28.33% in low category. Students' misconceptions are caused by wrong reasoning, intuition, humanistic thinking, preconceptions, and associative thinking. This five-tier diagnostic instrument can be used by physics teachers as an assessment instrument in physics learning. In addition, to fulfilling the evaluation and assessment objectives achievement, this instrument provides convenience in implementation, documentation, and track the causes of students' difficulties in understanding thermodynamic concepts.

Keywords: conception levels, five-tier e-diagnostic test, misconception, thermodynamic

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INTRODUCTION

In industrial era 4.0, information and communication technology is an important aspect of human life, because it can help human activities, especially when facing the physical distance of the Covid-19 pandemic. Towards the end of the pandemic, the implementation of the learning process in Indonesia has gradually changed from full-online (daring), to hybrid (mixed of online-offline), then in the last 2-3 months full offline (luring). The practice of learning during the pandemic using ICT, especially in assessment activities using the google form platform, provided significant benefits for teachers and students. The advantages of using google forms are that teachers can carry out the online learning evaluation process by making multiple-choice questions and descriptions and can see student scores quickly so that they can be followed up with remedial and enrichment (Heryadi, 2021). Assessment with electronic instruments is much easier to prepare, easy to distribute, controlled implementation

(Alruwais et al., 2018), well documented, flexible (Fitriyah & Jannah, 2021) and easily accessible by students they are used to and conditioned during the pandemic.

Learning during a pandemic makes students closer to technology. This is very in sync with the science of physics, where physics is one of the crucial subjects that play a role in technological development. The main key to studying physics is concept mastery which must be possessed by every student (Rafiqah et al., 2019), where each concept is well connected. If there is an error in understanding the concept, then it can affect other concepts. For example, when studying the concept of thermodynamics, students must understand the concepts of temperature, heat, and the kinetic theory of gases, then the relationship between these three concepts, and then master the concepts of thermodynamics. The results of interviews with students found that many of them did not fully understand the concepts of physics correctly and had difficulty understanding the material taught by the teacher. Of course, this will impact students, such as a decrease in learning achievement (Rafiqah et al., 2019). Students are expected to understand the material in theory and its application, not just memorizing (Agustin et al., 2017).

Students' understanding of a concept is called a conception. According to Malikha & Amir (2018), conception is the interpretation of a concept in one's mind and every time one gets a new concept, the concept will be processed and adapted to the concepts that have been previously owned. Every student has a different conception depending on his interpretation and perspective. Concept formation can occur through everyday life experiences such as the cooling process in a refrigerator that applies the concept of thermodynamics. If students have the same conception as the conception of scientists, then the student's conception can be categorized as a Scientific Conception (Marlis, 2015). If students experience misunderstandings about a concept to the point that it contradicts scientists' conception, then their understanding is categorized as a misconception. According to (Suparno, 2013) misconception is an understanding of a concept where there is a discrepancy with the concept recognized by experts, if it is not immediately corrected can hinder the formation of concepts in subsequent learning (Retno Artiawati et al. 2018). According to Purnama & Fakhruddin (2018), students experience high misconceptions on thermodynamic material, namely the concept of internal energy, work based on the P-V graph, the second law of thermodynamics, and the efficiency of the carnot engine.

Based on the data of the misconceptions that occurred in the students above, it is necessary to identify the level of conception and trace the students' misconceptions in the thermodynamic material so that conceptual misunderstandings can be corrected immediately. Concept maps, concept-related interviews, and diagnostic tests can be used to identify conception levels and track students' misconceptions (Ali, 2019). The most effective and efficient method is diagnostic tests (Salsabila & Ermawati, 2020). Diagnostic tests generally have a multiple choice format with tiered or stratified answers called tiers, where each level aims to track the correctness of the answers given by respondents. Currently, the format of the diagnostic test has grown to the fifth level (five-tier), with the first four-levels consisting of multiple choice answers and the last level being open answers. The first tier is the respondent's answer to the given question, the second tier is the respondent's belief in the answer given. The third and fourth-tiers, contain the respondent's reasons/arguments for the answers given in tier-2 and the respondent's beliefs on the choice of these reasons/arguments. The fifth tier is the respondent's open answer, and it can be in the form of a figure or statement that supports the answer in each tier, as well as a form of expression of knowledge and confirmation of the respondent (Qonita & Ermawati, 2020).

In order to identify misconceptions and levels of conception in Thermodynamics material, it has been reported the use of various diagnostic tests in various articles, including the one-tier diagnostic test has been used by Pratiwi et al. (2016), two tier multiple choice (TTMC) has been used Rahmi (2016), Purnama & Fakhruddin (2018) have used a three-tier

diagnostic test and Handayani et al. (2018) using four-tier diagnostic tests. It turns out that a five-tier diagnostic test on thermodynamics has not been reported yet. The advantage of this five-tier diagnostic test is that it provides more detailed tracking data, making the conclusions more accurate (Sari & Ermawati, 2021). Table 1 shows the criteria for the combination of five-tier format diagnostic test answers and their level of conception.

Table 1. Combination of answers in a five-tier format along with the level of conception (Anam et al., 2019; Amin et al., 2016)

No.	A combination of tier answers to-					Conception Levels
	1	2	3	4	5	
1.	C	S	C	S	StC PtC MoC UfC NC	SC ASC LK UnC
2.	C	S	C	NS		
3.	C	NS	C	S		
4.	C	NS	C	NS		
5.	C	S	IC	NS		
6.	C	NS	IC	S	PtC/ MoC/ UfC/ NC	LK
7.	IC	NS	IC	S		
8.	IC	S	C	NS		
9.	IC	NS	C	S		
10.	IC	NS	C	NS		
11.	IC	S	C	S		
12.	IC	NS	C	NS		
13.	IC	S	IC	NS	PtC/	
14.	IC	NS	IC	S	MoC/	NU
15.	IC	NS	IC	NS	UfC	
16.	IC	S	IC	S	MoC/ UfC/ NC	MSC
17.	Found tiers that were missed or answered more than one					UnC

Information:
C = Correct , IC = Incorrect, S = Sure, NS = Not Sure,
StC = Scientific Conclusion, PtC = Partial Conclusion, MoC = Misconception Conclusion, UfC = Undefined Conclusion, NC = No Conclusion.
SC = Scientific Conception, ASC = Almost Scientific Conception, LK = Lack of Knowledge, NU = No Understanding on Conception, MSC = Misconception, UnC = Un Code.

The following is an explanation regarding the symbols and the answer scores obtained in the fifth tier, shown in Table 2.

Table 2. The explanation regarding the symbols and the 5th tier answer scores is adapted from (Anam et al., 2019; Dikmenli, 2010; Köse, 2008)

No.	Symbol	Description	Score (%)
1.	*StC*	Students answer correctly according to the concept of physics	100
2.	*PtC*	Students answer partly correctly according to the concept of physics	99-70
3.	*MoC*	Students answered incorrectly and differed from the concept of physics	69-40

No.	Symbol	Description	Score (%)
4.	*UfC*	Incompatibility of student answers with concepts or cannot be understood	39-1
5.	*NC*	Students do not answer	0

Based on the description of the misconceptions experienced by students in Thermodynamics material (Purnama & Fakhruddin, 2018), so this research reports the results of the development of an electronic diagnostic instrument for thermodynamics in a five-tier format based on google form, to find a conception level profile and trace the existence of misconceptions and their causes, considering that until now this instrument has not been available.

METHOD

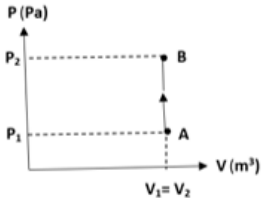
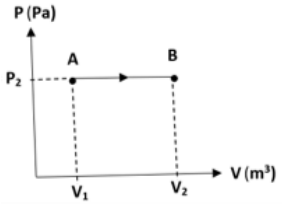
Research Design

This research used to research and development (R&D) methods to produce a certain instrument and test the instrument's effectiveness (Sugiyono, 2013). Stages of R&D (Sugiyono, 2013) namely: 1) potential and problems, 2) information gathering, 3) instrument design, 4) instrument design validation, 5) instrument design revision, 6) instrument trial, 7) instrument revision, 8) second trial, 9) revision instruments and 10) large-scale instrument manufacture. Due to time constraints, this research applied eight stages (1 to 8).

Potential and problem analysis was carried out through direct observation at a tutoring center in the early stages based on previous research data. Thermodynamics material is one of the difficult materials for students so they have test scores that have not met the complete criteria. Based on previous research (Purnama & Fakhruddin, 2018), it was found a very high misconception. After knowing the potential problems, they gather information related to these problems through literature studies to determine the right instrument design. At this stage, a review of the thermodynamic material literature is carried out, especially on the concept of internal energy, thermodynamic processes, work, and thermodynamic cycles both from physics textbook sources (Abdullah, 2016; Serway & Vuille, 2013) as well as from previous research (Purnama & Fakhruddin, 2018; Rahmi, 2016; Handayani et al., 2018). The research of these sources was continued to map the misconceptions on thermodynamic material. The following are some results of the recapitulation of potential misconceptions in Thermodynamics material.

Table 3. Some potential misconceptions about Thermodynamics

Sub Concept	The Correct Concept	Potential Misconceptions
Thermodynamic Process (Isobaric Process)	The isobaric process is the process of changing the state of the system at constant pressure. The temperature increases as the volume change during the process (directly proportional) (Abdullah, 2016) $P\Delta V = nR\Delta T$ (1) Information: P = Pressure (N/m^2) ΔV = Volume Change (m^3) n = Number of moles (mol) R = Gas determination (8,31 J/molK) ΔT = Temperature Change (K)	The isobaric process changes the state of the system at constant pressure, then the temperature and volume changes are reversed during the process.
Thermodynamic Process (Isochoric	The isochoric process changes the state of the system at a constant volume (Abdullah, 2016). This process has a graph with a character	An isochoric process changes the state of the system at constant

Sub Concept	The Correct Concept	Potential Misconceptions
Process)	perpendicular to the V axis.  	volume with a graph with a line parallel to the V axis. 
Thermodynamic Cycle (Efficiency and performance coefficient)	The coefficient of performance is inversely proportional to efficiency, where the efficiency value is close to 100%. $\eta = \frac{1}{\varepsilon} - 1$ (2) The greater the value of the performance coefficient, the better the quality of a machine. (Abdullah, 2016)	The coefficient of performance is proportional to efficiency, where the efficiency value is absolutely 100%.

The third stage is to create a product design. At this stage, the first draft was compiled in the form of a google-form-based three-tier e-diagnostic test to capture student reasons. After searching for reasons and completing various literature studies, a final draft of 12 test items was obtained in a five-tier format based on the google form. Next, validate the instrument design through validity and reliability tests. Three UNESA physics lecturers carried out internal validation on the instrument questions and questionnaire responses to instrument users. The data obtained were then analyzed and used as a reference to revise the instrument. In the fifth stage, the design was revised according to the corrections and suggestions of the validator. The sixth stage conducted a trial on 27 students to obtain external validity and instrument reliability. The results of external validation and the reliability of the five-tier e-diagnostic test were obtained from the test data. The next stage is to revise the instrument that has been tested. The second instrument improvement was carried out on the instrument presentation structure so that it was easy for students to understand. In the final stage, the instrument that was valid and reliable was applied to 20 students to obtain research data in accordance with the research objectives, namely to obtain data on the level of students' conceptions and levels of misconceptions on thermodynamic material. In addition, it's obtaining responses to the use of a five-tier e-diagnostic instrument based on the google form.

Subject

In this research, to capture the reasons for the answers involved 7 students who live in Bojonegoro, Probolinggo, and Surabaya. Then, to test the instrument, it was carried out on 27 students of 11th Grade of Madrasah Aliyah Negeri 1 Bojonegoro to get the external validity and reliability of the instrument. Research data were obtained from 20 students of 11th Grade of MA Negeri 1 Bojonegoro to identify the conception levels, track misconceptions in thermodynamic material, and respond to research instruments.

Instrument, Procedure and Data Analysis

In the first draft, 12 diagnostic questions were arranged in a three-tier format with open reasons to collect reasons for answers. Then the trial result were developed in the second draft in a five-tier format. In the second draft, which consisted of 12 questions, the internal validity test of the student's question instrument, both in terms of content validity, construction and grammar, was carried out by three UNESA physics lecturers. Table 4

presents the scoring rubric for the internal validity of the instrument for each question indicator. In contrast, Table 5 shows the rubric for scoring the internal validity of the instrument user's response questionnaire.

Table 4. Rubric for scoring the internal validity of the question instrument and the interpretation of the score (Riduwan & Akdon, 2013)

Scoring Rubric	Score Interpretation (%)
1	0 – 39 fulfilled
2	40 – 69 fulfilled
3	70 – 89 fulfilled
4	90 – 100 fulfilled

Table 5. Scoring rubric for the internal validity of instrument user response questionnaires (Djaali, 2008)

Score	Category
1	Very Disagree (VD)
2	Disagree (D)
3	Neutral (N)
4	Agree (A)
5	Very Agree (VA)

The results of the validity of the internal instrument questions are processed using the Eq. 3 (Arikunto, 2016) while the response questionnaire uses Eq. 4.

$$P = \frac{S_R}{N \,.\, P_A \,.\, R} \times 100\% \qquad (3)$$

$$P = \frac{Total\ Skor}{Skor\ Maksimum} \times 100\% \qquad (4)$$

Informations:
P = validity percentage
S_R = total score from the validator
N = highest score of each aspect
P_A = total of questions per aspect
R = total validator

The results of the internal validity are then interpreted based on Table 6.

Table 6. Interpretation of internal validity (Riduwan & Akdon, 2013)

Percentage (%)	Interpretation Validity
0 – 20	Very invalid
21 – 40	Invalid
41 – 60	Enough valid
61 – 80	Valid
81 – 100	Very valid

The validation made improvements to the draft so that the third draft (12 items) was obtained and tested on 27 students to obtain external validity consisting of empirical content, construct validity, and reliability. Empirical content validity was obtained by calculating the % false negative (FN) and false positive (FP). FN occurs if the answer is wrong and sure, but the reason for the answer (tier 3) is correct and the question (tier 5) is answered incorrectly. FP occurs when students answer correctly and confidently, but the reasons for answering (tier 3) and questions (tier 5) are answered incorrectly. Theoretically, the empirical validity of the

content is met if %FP and %FN are less than 10%, respectively (Zahra & Suprapto, 2019) %FP and %FN are calculated using Eq. 5 (Kirbulut & Geban, 2014).

$$\% X = \frac{\Sigma X}{\Sigma items \times \Sigma \text{ PD}} \times 100\% \quad (5)$$

Informations:

ΣX = Total FN or FP

$\Sigma items$ = Total items

Σ PD = Total respondent (students)

According to (Arikunto, 2013), the empirical validity of the construct was obtained using Eq. 6 and its reliability using Eq. 7 (Arikunto, 2016).

$$r_{xy} = \frac{\Sigma xy}{\sqrt{(\Sigma x^2)(\Sigma y^2)}} \quad (6)$$

Informations:

r_{xy} = correlation coefficient between variables x and y

x = correct answer score on each question (tier 1 & 3)

y = sure answer scores at each confidence level (tier 2 & 4)

$$r_{11} = \frac{k}{k-1}\left(\frac{\Sigma \sigma_b^2}{\sigma_t^2}\right) \quad (7)$$

Informations:

r_{11} = reliability coefficient

k = total item

σ_b^2 = score variance for each item

σ_t^2 = total variance

The following is the interpretation of the correlation coefficients in Table 7 and the reliability criteria in Table 8.

Table 7. Interpretation of correlation coefficient results (Sugiyono, 2015)

Correlation coefficient (r_{xy})	Interpretation Criteria
0.800 - 1.000	Very high
0.600 - 0.799	High
0.400 - 0.599	Medium
0.200 - 0.399	Low
0.000 - 0.199	Very low

Table 8. Interpretation of reliability (Sugiyono, 2015)

Reliability coefficient (r_{11})	Interpretation Criteria
0.800 - 1.000	Very high
0.600 - 0.799	High
0.400 - 0.599	Medium
0.200 - 0.399	Low
-1.000 - 0.199	Very low

The results of the external validity and reliability test resulted in a final draft in the form of a five-tier e-diagnostic test based on the google form. The final draft was then used on 20 students to identify the level of conception and track students' misconceptions on thermodynamic material. The percentage level of conception is calculated using Eq. 8 (Sudijono, 2014) as follows:

$$\% = \frac{Nb}{Nk} \times 100\% \quad (8)$$

Description:

% = Percentage conception levels

Nb = Total of part

Nk = Total item

From these percentages, it can be identified that students experience the highest level of conception according to specific criteria in Table 1 and can also group the level of misconceptions according to the percentage in Table 9.

Table 9. Misconception level percentage criteria (Istighfarin et al., 2015)

Percentage (%)	Criteria
0 – 30	Low
31 – 60	Medium
61 – 100	High

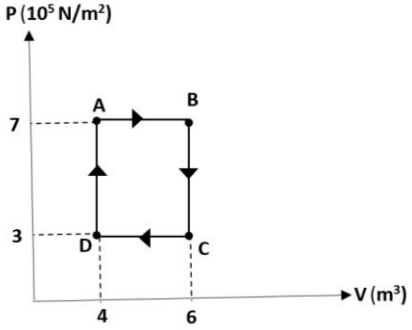
Responses to the use of google form media in the form of opinions, criticisms, and suggestions related to the five-tier e-diagnostic based on google form were analyzed using Microsoft Excel according to the Eq. 4 and Table 5.

RESULTS AND DISCUSSION

Development of five-tier e-diagnostic test

The results of the development of five-tier e-diagnostic test obtained 12 items that were declared eligible to be used. One of the questions in question is set out in Table 10 below.

Table 10. One of the 12 questions of the five-tier e-diagnostic test

Tier to-	Question
1	Take a look at the P-V chart below!  It is known that the total work done from A-B-C-D-A is 800 kJ. How much work is required from A-B-C-A? A. 200 kJ B. 400 kJ C. 800 kJ D. 1.200 kJ E. 4.200kJ
2	Your level of confidence in choosing an answer: A. Sure B. Not Sure
3	Reason for choosing the answer: A. Because the amount of work is equal to the total circumference of the area on the graph *(Wrong intuition)* B. Because the amount of effort is the same as the C-A cycle *(Humanistic thinking)* C. Because the amount of work is equal to the total area on the graph *(Pre-conception)* D. Because the amount of work is equal to the area covered by the cycle curve on the graph *(Scientific conception)* E. Because the amount of work is equal to the area of the area not covered by the cycle curve on the graph *(Associative thinking)*

Tier to-	Question
	F. Because the amount of work is equal to the circumference of the area enclosed by the cycle curve on the graph *(Wrong reasoning)*
4	Your level of confidence in choosing a reason: A. Sure B. Not Sure
5	Write down how to solve the problem! Answer:

Based on Table 10, tier 1 consists of questions with 5 answer options. Tier 2 states the confidence level in answering questions with 2 answer options. Tier 3 is the reason for choosing an answer with 6 answer options. The reason choice is made to deceive based on the causes of misconceptions such as humanistic thinking, associative thinking, preconception, wrong intuition, and wrong reasoning. Tier 4 consists of the confidence level in choosing the reason for the answer with 2 answer options. Tier 5 consists of open questions to confirm and draw conclusions about the answers to the questions so that students can anticipate students guessing answers (Salsabila & Ermawati, 2020). In addition, the use of google forms for this diagnostic test has a different format because it uses internet media, requiring an internet connection or quota to work on the problem. Here is a figure of one of the five-tier e-diagnostic test questions based on the google form.

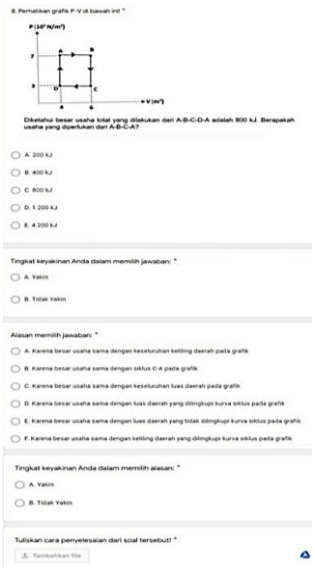


Figure 1. The display of one of the five-tier e-diagnostic test questions on the google form

For filling out tier 1 to 4 answers in google form-based five-tier e-diagnostic test instrument, it's by clicking on the answer on the options provided. In contrast, in tier 5 it is done on a piece of paper then take a photo of the working paper and upload it as an image format (JPG/JPEG) in the space provided.

Validity and reliability of five-tier e-diagnostic test

Tables 11 to 13 sequentially present the results of the recapitulation of internal validity, empirical content, and construct external validity.

Table 11. Recapitulation of the results of the internal validity of the five-tier e-diagnostic test

No.	Aspect	Indicator	Validator			(%)	Validity
			1	2	3		
1.	Contents	a	4.00	4.00	4.00	93.75	Very Valid

		b	4.00	4.00	3.33		
		c	4.00	4.00	3.58		
		d	3.00	3.67	3.42		
		a	4.00	4.00	4.00		
		b	3.75	3.83	3.50		
2.	Construct	c	2.75	4.00	3.58	90.85	Very Valid
		d	3.67	4.00	2.67		
		e	3.50	3.75	3.00		
		f	3.83	4.00	3.58		
		a	4.00	3.75	3.67		
3.	Language	b	4.00	3.75	3.42	96.02	Very Valid
		c	4.00	3.83	3.67		
		d	4.00	4.00	4.00		
Average						**93.54**	**Very Valid**

Based on Table 11, the instrument developed is classified as very valid in accordance with Table 6. So it can be continued by conducting an external validity test.

Table 12. The results of the external empirical validity of the contents of the five-tier e-diagnostic test

No. Question	ΣFP	ΣFN	ΣPD
1	1	1	27
2	3	0	
3	3	2	
4	2	0	
5	2	1	
6	0	3	
7	4	0	
8	0	1	
9	0	1	
10	5	1	
11	2	2	
12	3	1	
Total	**25**	**13**	
%	**7.71%**	**4.01%**	

Based on Table 12, the percentage of FP and FN is less than 10%, then the draft has met the criteria for empirical validity of content (Zahra & Suprapto, 2019).

Table 13. The results of the external construct validity and reliability of the five-tier e-diagnostic test

No.	r_{xy}	r_{table}	Validity	r_{11}	Reliability
1	0.650		valid		
2	0.471		valid		
3	0.479	0.381	valid	0.601	High
4	0.745		valid		
5	0.419		valid		

No.	r_{xy}	r_{table}	Validity	r_{11}	Reliability
6	0.679		valid		
7	0.413		valid		
8	0.540		valid		
9	0.547		valid		
10	0.481		valid		
11	0.694		valid		
12	0.474		valid		

From Table 13 it can be concluded that the 12 items are valid because the value of $r_{xy} > r_{table}$ and reliable because $r_{11} > r_{table}$. The value of r_{table} is obtained through the number of respondents, 27 people, so it is worth 0.381 with a significance level of 5%. Given that the five-tier e-diagnostic test instrument is valid and reliable, the instrument can be tested on students to obtain the level of conception.

Conception levels of students

The conception level test activity was carried out on 20 students who had received thermodynamics material. The following Diagram 1 shows the number of students based on the conception level criteria for each item.

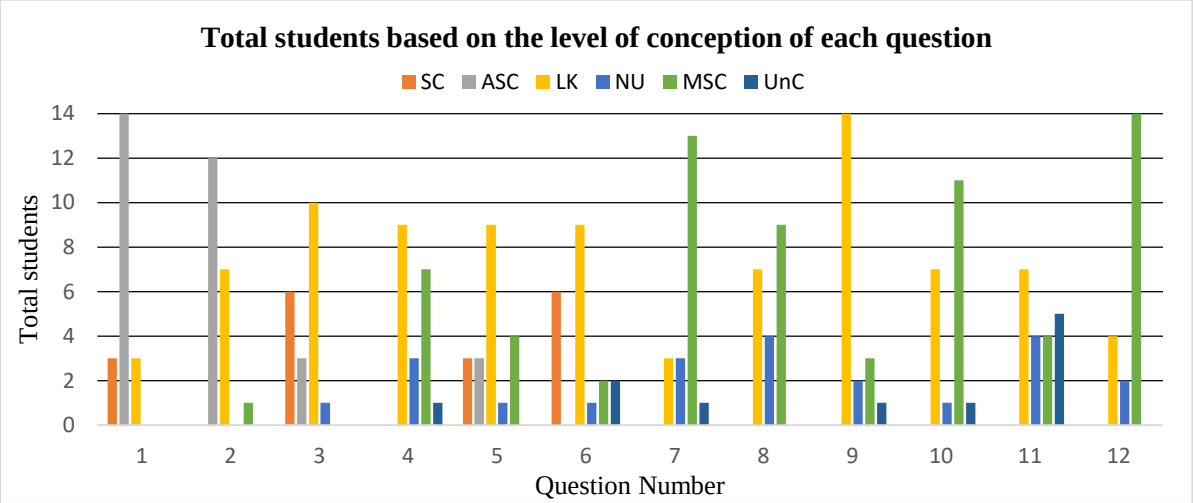


Figure 1. The number of students based on the criteria for the level of conception in each item

From the number of students at the conception level, the percentage of each level of conception can be calculated as shown in Table 14.

Table 14. Percentage of conception levels for each item

No. Question	Percentage of Conception Levels (%)					
	SC	ASC	LK	NU	MSC	UnC
1	15	70	15	0	0	0
2	0	60	35	0	5	0
3	30	15	50	5	0	0
4	0	0	45	15	35	5
5	15	15	45	5	20	0
6	30	0	45	5	10	10
7	0	0	15	15	65	5

No. Question	Percentage of Conception Levels (%)					
	SC	ASC	LK	NU	MSC	UnC
8	0	0	35	20	45	0
9	0	0	70	10	15	5
10	0	0	35	5	55	5
11	0	0	35	20	20	25
12	0	0	20	10	70	0
% Total	**7.50**	**13.33**	**37.08**	**9.17**	**28.33**	**4.58**

Based on Table 15, the highest level of conception is dominated by Lack of Knowledge (LK). The questions with the highest percentages at the SC level are numbers 3 and 6. At the ASC level, the highest percentage is at number 1. While at the LK level the highest percentage is at number 9. The NU level has the highest percentages in question numbers 8 and 11. The highest percentage of MSC level is at number 12 and the UnC level is at number 11.

Misconceptions in students

In addition to identifying the level of conception, this research also tracks the misconceptions that occur in students. Misconceptions occur in all sub-concepts: internal energy, thermodynamic processes, work, and thermodynamic cycles. Figure 2 shows one of the answers from students on one of the concepts, namely the sub-concept of work.

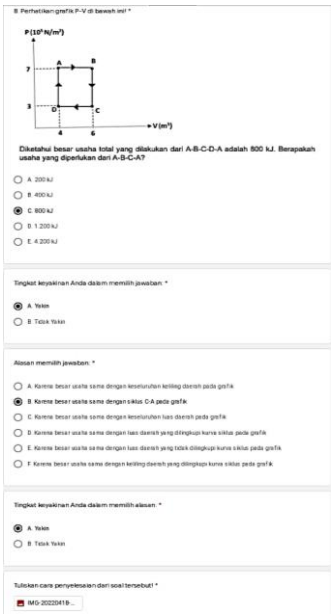


Figure 2. The answer of one of the students on the google form-based five-tier e-diagnostic test

Based on Figure 2, it can be stated that these students are classified having misconceptions caused by preconceptions. The following table 15 shows the percentage of misconceptions experienced by these students.

Table 15. The percentage of misconceptions in each item along with the criteria

No. Question	MSC (%)	Criteria
1	0	Low
2	5	Low

No. Question	MSC (%)	Criteria
3	0	Low
4	35	Medium
5	20	Low
6	10	Low
7	65	High
8	45	Medium
9	15	Low
10	55	Medium
11	20	Low
12	70	High
Average	**28.33**	**Low**

Based on Table 15, the average percentage of misconceptions is relatively low. The highest percentage of misconceptions is found in question number 12, namely the sub-concept of thermodynamic cycles, while the low criteria are found in questions 1 and 3 on the sub-concept of internal energy and thermodynamic processes. The causes of misconceptions in students are dominated by wrong reasoning with 34.93%.

Relevant research was also carried out to identify misconceptions in the laws of thermodynamics using the four-tier diagnostic test conducted by Handayani et al. (2018), where the percentage of misconceptions is 28.04% which is relatively low. Another research using Three-Level Multiple Choice (Purnama & Fakhruddin, 2018), the percentage of misconceptions is 54.67%, while Two-Tier Multiple Choice (TTMC) with the percentage of misconceptions is 16.86% (Rahmi, 2016). Based on the results of this research, it can be concluded that there are differences in the percentage of misconceptions due to schools differences and the level of students understanding on thermodynamic material. In addition, the level of conception obtained is also different, there are five groupings of conception levels in the five-tier format, which there are additional levels of conception, namely Lack of Knowledge, Almost Scientific Conception, and Un Code. Meanwhile, in research by Handayani et al. (2018), there are 3 categories of conception, namely understanding concepts, misconceptions, and not understanding concepts, while researches conducted by Purnama & Fakhruddin (2018) and Rahmi (2016) , there are four categories of conception with the addition of guessing categories.

Student response to google form-based five-tier e-diagnostic test

In this research, google form was used to assess students' conceptions, so an analysis of its effectiveness was needed. Table 16 shows the internal validity of the student response questionnaire.

Table 16. Internal validity of the response questionnaire and its criteria

No.	Aspect	Indicator	Validator			Percentage (%)	Criteria
			1	2	3		
1.	Charging instructions	a	5	4	5	93.33	Very Valid
		b	5	4	5		
2.	Content	a	4	4	3	77.78	Valid
		b	4	4	4		
		c	4	4	4		
3.	Language	a	5	4	5	85.00	Very Valid
		b	5	3	4		
		c	5	3	4		

No.	Aspect	Indicator	Validator			Percentage (%)	Criteria
			1	2	3		
		D	5	4	4		
		Rata-rata				**85.37**	**Very Valid**

From Table 16, it was found that the validity of the response questionnaire was classified as very valid, so it was feasible to distribute to students to obtain responses from instrument users. From the responses of 20 students, the average questionnaire response was 4 with agreed criteria. As for some of the opinions of students regarding the use of google forms, among others: 1) it is more organized and easy to use, 2) it is not complicated, 3) it is more interesting, 4) paperless (questions are usually unclear when printed), 5) flexible, 6) easier to understand and more effective to use. However, the use of google forms also has drawbacks, such as students can use the 3rd application and it is not efficient when the internet network is unstable. So from the advantages and disadvantages of the google form-based five-tier e-diagnostic test, the author also asked for criticism and suggestions from students. There were some criticisms related to the instrument, such as the time given was too short and the questions presented were too difficult and quite a lot. In contrast, suggestions were such as reducing questions and increasing time in processing.

CONCLUSION

Based on the results of data analysis, it can be concluded that this research succeeded in developing 12 items of google form-based five-tier e-diagnostic test on thermodynamic material that has been valid and reliable so that it is feasible to use. In addition, the instrument can identify the level of conception and track students' misconceptions regarding thermodynamic material. The level of conception possessed by each student is different, where the percentage of the highest conception level is dominated by Lack of Knowledge of 37.08% and the average misconception is 28.33% which is relatively low. Students' misconceptions are caused by wrong reasoning, wrong intuition, humanistic thinking, preconceptions, and associative thinking. Five-tier e-diagnostic test can be used to achieve evaluation and assessment objectives. In addition to being effective, it also provides convenience in implementation and documentation and can track the causes of student difficulties in understanding thermodynamic concepts.

RECOMMENDATION

Physics teachers can use five-tier e-diagnostic test as assessment instrument for physics learning. In addition, this instrument can also identify the level of conception and track students' misconceptions on thermodynamic material. So from this data, the teacher can find out the difficulties experienced by students in thermodynamic concepts, especially students who have misconceptions about the material, and to provide the best learning solutions so that students do not experience misconceptions.

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