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Review and Comparison of Four-Tier Multiple Choice and Five-Tier Multiple Choice Diagnostic Tests to Identify Mastery of Physics Concepts

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Abstract: Misconceptions of a concept in a lesson will have an influence on understanding the next concept. Having misconceptions that exist in learning can understand the nature of the misconceptions and consequently can help student learning progress. Therefore, a diagnostic test for misconceptions is needed, including the newest four-tier multiple-choice and five-tier multiple-choice. This research is a literature review that provides an information system using the PRISMA method which often occurs in students' misconceptions in high school physics subjects. The data for this research are 60 selected articles from 2017-2021. The purpose of this study is to reveal the use of four-tier multiple-choice and five-tier multiple-choice diagnostic tests in physics and also provide a comparison of each instrument with the strengths and weaknesses of the four-tier multiple-choice and five-tier multiple-choice diagnostic tests. Furthermore, the use of multiple-choice four levels (83.33%) and multiple-choice five levels (16.67%). In the use of the four-tier multiple choice physical material diagnostic test, which is often used in identifying misconceptions, are optical devices (12%) and energy businesses (10%). And the use of an additional five-tier multiple-choice instrument diagnostic test that is often used is to present an overview or conclusion at the fifth level. However, each type of four-tier multiple-choice and five-tier multiple-choice test has its own advantages and disadvantages in assessing students' conceptions.

Keywords: Misconception; four-tier multiple-choice; five-tier multiple choice

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Introduction

Misconceptions in learning physics have a very large impact or influence. Misconceptions in physics learning by students will affect subsequent physics learning (Mufit, 2019). Therefore, a diagnostic test is needed so that teachers do not misinterpret students' misconceptions. Diagnostic tests are instruments to explain the difference between what they should know and what they know about the material being studied by students (Gurel, et al, 2015) so that teachers can give proper treatment to students. Diagnostic tests are used to diagnose misconceptions that occur in students. Diagnostic tests consist of various means such as interviews, open-ended questions, and multiple choice. Multiple choice diagnostic tests have several types including simple multiple-choice tests, two-tier multiple-choice tests, three-tier multiple-choice tests, and four-tier multiple-choice tests (Soeharto, 2019).

The first level is a multiple-choice question consisting of one correct key and three distracting answers. The second level is multiple choice questions by adding the level of confidence to the previous answers. The third level is multiple choice questions with a level of confidence plus the reasons or opinions of students in determining the answer choices. The

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fourth level is multiple choice level three by adding the level of students' confidence in giving reasons for their answers. Among the advantages of multiple-choice four levels, the teacher can distinguish the level of student confidence in giving answers and the teacher can also distinguish the level of student confidence in giving opinions or reasons, teachers can diagnose misconceptions that arise in students, teachers can also analyze parts of the material that need to be emphasized and finally, teachers can design appropriate and better learning to improve students' understanding of concepts (Fariyani, 2017). This is the same as stated in Kaltakci's research that the four-level multiple-choice test is an appropriate choice for identifying misconceptions (Kaltakci, et al., 2015).

Although the four-level multiple-choice diagnostic test provides clear information and also helps in student learning progress. However, the four-level multiple-choice instrument does not provide an opportunity for students to express their understanding. Thus, this becomes additional information for the teacher, about what concepts students understand and think. (Anam, 2019). In addition, the four-level multiple-choice instrument could not find out the sources used by students in answering the previous questions. According to Inggit, (2021) to determine the right learning design, it is necessary to know the source of the causes of misconceptions. So, this deficiency is the reason for the birth of the five-tier multiple-choice diagnostic test. The five-tier multiple-choice is developed according to learning needs. With additional instruments in identifying misconceptions in students, teachers can analyze misconceptions more deeply and can improve progress in learning.

The limitation of the problem in this literature review study is that the researcher only conducts a comparative study of the latest multiple-choice diagnostic tests that are often used in identifying students' misconceptions in high school physics subjects. This research has three main objectives. First, analyzing the number of articles in high school physics learning that uses four-tier multiple choice and five-tier multiple choice diagnostic tests in identifying students' misconceptions. Second, analyzing the material in high school physics learning using a four-tier multiple choice diagnostic test in identifying students' misconceptions. Third, analyzing the material in high school physics learning using a five-tier multiple-choice diagnostic test in identifying students' misconceptions. Fourth, analyze the comparison of four-tier multiple-choice and five-tier multiple-choice diagnostic tests.

Method

This study uses a literature review method or literature review. Literature review is a systematic and structured method used to analyze, identify, and synthesize research results and thoughts produced by researchers (Soeharto, 2019). Researchers collect data through databases such as Google Scholar, ResearchGate, Sinta and Garuda. After collecting data through the database, so that the review process runs systematically, this literature review uses the PRISMA method, namely Preferred Items for Systematic Review and Metanalysis introduced by Moher, et al (2009). This method has the following steps: (1) identifying the criteria for the article to be analyzed; (2) perform an article search; (3) conduct a search and screening to identify important studies; (4) examine the feasibility of the selected articles; and (5) describe, analyze, and synthesize the study. The use of the PRISMA method in obtaining the desired articles in this study can be explained in Figure 1.

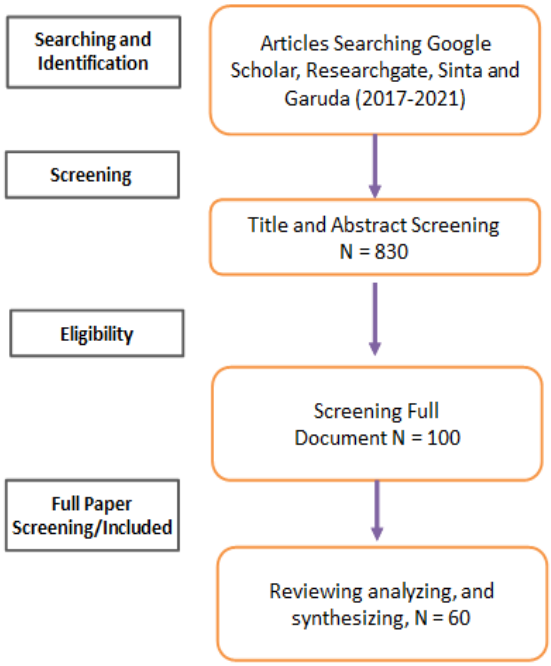

Figure 1. PRISMA Flowchart (source: Suharto modification, 2019

Figure 1. shows how to determine the article to be researched using the PRISMA steps. During the search process through databases such as Google Scholar, ResearchGate, Sinta, and Garuda. There are about 830 related studies when writing with the keywords "Diagnostic Test", "four-tier multiple choice" and "five-tier multiple choice". From the journals that appeared, the researchers conducted a screening by determining the inclusion and exclusion criteria. In the inclusion criteria, the researchers set the following

criteria: (1) articles using English and Indonesian, (2) types of articles used in research articles, (3) articles can be downloaded in full. While the exclusion criteria applied were articles on high school physics subjects published from 2017-2021. The researcher then determines the articles that will be used as literature review materials that have met the eligibility, namely the articles must be based on original research, the article has a discussion about four-tier multiple-choice and five-tier multiple-choice in physics subjects. The findings in articles that meet the eligibility for international standards are 48 findings, while in articles with national standards there are 12 findings.

Then, in analyzing the article using a descriptive statistical approach adopted to find the percentage of instruments that use four-tier multiple-choice and five-tier multiple-choice in physics subjects. The next step is to analyze the physics material or misconceptions with a four-tier multiple-choice instrument from each article. The researcher also analyzed physics material or misconceptions with a five-tier multiple-choice instrument from each article. In the next stage, the researchers analyzed the similarities, differences and gave their own opinion regarding the four-tier multiple-choice and five-tier multiple-choice instruments.

The review process is carried out iteratively and gradually. Articles were researched based on abstracts, instruments, and the results of the analysis of misconceptions. The main discussion of test assessment in the paper is used as a data instrument to compare the strengths and weaknesses of each study. In conducting a literature review, the researcher paid special attention to the types of four-tier multiple-choice and five-tier multiple-choice instruments because of the novelty and frequent use of these tests.

Result and Discussion

Result

To find out or identify students' misconceptions in studying high school physics concepts, a teacher can use a diagnostic test that has been developed. Among the diagnostic tests in measuring students' misconceptions are interviews, open-ended questions, simple multiple-choice tests, two-tier multiple-choice tests, multiple-choice tests three-tier, four-tier multiple-choice tests, and the latest five-tier multiple-choice. In the diagnostic test in identifying students' physics misconceptions, it was found that the four-level and five-level multiple-choice tests were the newest and most frequently applied diagnostic tests. However, each diagnostic test still has various characteristics, advantages, and disadvantages.

Table 1. The proportion of Multiple-Choice Diagnostic Instruments at four levels and five levels in assessing and identifying high school physics misconceptions

Graded Multiple Choice Test	Total	Percen-tage (%)
Four-Tier Multiple Choice	50	83.33
Four-Tier Multiple Choice	10	16.67
Total	60	100

Table 1. shows the percentage of articles that examine multiple-choice diagnostic tests in identifying misconceptions about physics concepts for high school students. Based on 60 studies of four-level and five-level multiple-choice diagnostic tests in 2017 to 2021, it was found that the four-level multiple-choice test was most often used with the number of articles found by 50 articles (83.33%) and the five-level multiple-choice test with the number of findings 10. articles (16.67%).

The following table shows the material misconceptions of high school physics reviewed in journals that were found using a four-level multiple-choice test.

Table 2. Four Level Multiple Choice Test in assessing high school physics misconception

No	Misconception Material Materi	Class	Reference	Total	%
1.	Straight Motion	X	(Rahayu, P., & Hariyono, E. 2019; Erwinsyah, H., Muhassin, M., & Asyhari, A. 2020; Setiawan, D. 2020; Triastutik, M., Budiyono, A., & Diraya, I. 2021)	4	8
2	Circular Motion	X	(Annisa, R., Astuti, B., & Mindyarto, BN 2019; Bhakti, YB 2021)	2	4
3	Style Concept	X	(Maharani, L, et al. 2019; Sundaygara, C., Gusi, LARP, Pratiwi, HY, Ayu, HD, Jufriadi, A., & Hudha, MN 2021, Zulfikar, A., Samsudin, A., & Saepuzaman, D. 2017)	3	6
4	Gravity	X	Izzah, N. (2019).	1	2
5	Work and Energy	X	(Anggrayni, S., & Ermawati, FU 2019; Boro, AM, Okyranida, IY, & Astuti, IAD 2020; Hasran, SH, Eso, R., Takda, A., & Ute, N.2021; Jubaedah, DS , Kaniawati, I., Suyana, I., Samsudin, A., & Suhendi, E. 2017; Rukmana, AP, Mayasari, T., & Yusro, AC 2020)	5	10
6	Momentum and Impulse	X	(Hanifah, L., & Ermawati FU 2019; Nasyidiah, FI, Siahaan, P., & Sasmita, D. (2020)	2	4

No	Misconception Material Materi	Class	Reference	Total	%
7	Simple Harmonic Vibration	X	(Guswina, S., & Mufit, F. 2020; Tumanggor, AMR, Supahar, S., Ringo, ES, & Harliadi, MD 2020).	2	4
8	Rotation Dynamics	XI	(Furoidah, A., & Bachtiar, RW 2017; Jannah, EM, & Ermawati, FU 2019; Jannah, EM, & Ermawati, FU 2020; Oktavia, VE, & Admoko, S. 2019).	4	8
9	Static Fluid	XI	(Cahyani, H., et al 2019; Diani, R., Alfin, J., Anggraeni, YM, Mustari, M., & Fujiani, D. 2019; Isfara, L., & Ermawati, FU 2018; Sholahuddin, S. Rusnayati, H., & Suyana, I. 2019	4	8
10	Dynamic Fluid	XI	(Aprita, DF, Supriadi, B., & Prihandono, T. 2018; Kurniawati, DM, & Ermawati, FU 2019; Sholihat, FN, Samsudin, A., & Nugraha, MG 2017;	3	6
11	Temperature and Heat	XI	(Utari, JI, & Ermawati, FU 2018; Fenditasari, K., & Istiyono, E. 2020; Maison, M., Safitri, IC, & Wardana, RW 2019).	3	6
12	Thermodynamics	XI	(Handayani, ND, Astutik, S., & Lesmono, AD 2018)	1	2
13	Kinetic Theory of Gas	XI	(Zahra, Y., & Suprapto, N. (2019)	1	2
14	Wave	XI	(Negoro, RA, & Karina, V. 2019; Roistiya, H., Putra, IA, & Pertiwi, NAS 2019; Sufiani, Y., Erniwati, E., & Eso, R.2019; Widiyanto, A., Sujarwanto, E., & Prihaningtiyas, S. 2018	4	8
15	Optical Instrument	XI	(Jannah, R., & Rahmi, I. 2020; Paramitha, D., Maison, M., & Darmaji, D.2021; Putra, AS, Hamidah, I., & Nahadi, N. 2019; Rawh, P., Samsudin, A., & Nugraha, MG 2020; Rohmanasari, F., & ERMAWATI, FU 2019; Sheftyawan, WB, Prihandono, T., & Lesmono, AD 2018.	6	12
16	Dynamic electricity	XII	(Aisahsari, R., & Ermawati, FU 2019; Ismail, II, Samsudin, A., Suhendi, E., & Kaniawati, I. 2015)	2	4
17	Static electricity	XII	(Lestari, INM, Suyana, I., & Jauhari, A. 2018).	1	2
18	magnetic field	XII	(Ramadhan, D., et. al 2019)	1	2
19	Alternating Current	XII	(Agustin, RD, Harijanto, A., & Prastowo, SHB 2018).	1	2
Total				50	100

Table 2. shows that there are about 50 research journals on the fourth-level multiple-choice test in identifying misconceptions about high school physics material. The application of four-level multiple-choice diagnostic tests on high school physics material is evenly distributed at every level of grade 10, grade 11, and grade 12. In other words, the use of four-level multiple-choice diagnostic tests can be used in every high school physics material. Physics materials that are often used in identifying high school physics concepts based on the journals studied are Optical Instruments with 6 studies (12%) and Work and Energy with 5 studies (10%). The table 3 describes findings of journals that use a five-tier multiple-choice diagnostic test on high school physics material.

Table 3. Five-tier diagnostic tests on high school physics

No	Misconception Material Materi	Classes	Reference	Fifth Level
1.	Vector Concept	X	(Qonita, M., & Ermawati, FU 2020).	Drawing and Conclusions
2	Circular Motion	X	(Ramadhani, NN, & Ermawati, FU 2021)	Drawing and Conclusions
3	Newton's Law	X	(Rosita, I., Liliawati, W., & Samsudin, A. 2020).	Answer Source
4	Simple Harmonic Vibration	X	Putri, WK, & Ermawati, FU (2021).	Drawing and Conclusions
5	Elasticity	XI	(Salsabila, FN, & Ermawati, FU 2020)	Drawing and Conclusions
6	Static Fluid	XI	(Inggit, SM, Liliawati, W., & Suryana, I. 2021)	Answer Source
7	Heat transfer	XI	Anam, RAS, Widodo, A., Sopandi, W., & Wu, HK (2019)	Drawing and Conclusions
8	Kinetic Theory of Gas	XI	FAJRIYYAH, NS, & ERMAWATI, FU (2020).	Drawing and Conclusions
9	sound wave	XI	Lailiyah, S., & Ermawati, FU (2020).	Drawing and Conclusions
10	Waves and Optical Instruments	XI	Putra, ASU, & Hamidah, I. (2020,	Answer Source

From Table 3. there are 10 journals in identifying students' conceptual misconceptions by using a five-level multiple-choice diagnostic test that has just been spread on physics material for grade 10 and grade 11.

The use of the fifth level in the five-tier multiple-choice diagnostic test there are two types of instruments, namely students provide explanations with pictures or provide conclusions on the concepts they have and students mention the source of the concepts obtained. Explanation by providing an overview or providing conclusions turns out to be more often used than determining the source of the concept that students get. Additional uses for providing drawings and conclusions are found in vector concepts, circular motion, vibration, elasticity, heat transfer, gas kinetic theory, and sound waves. As an example of the use of a five-level multiple-choice instrument conducted by Anam, et al (2019).

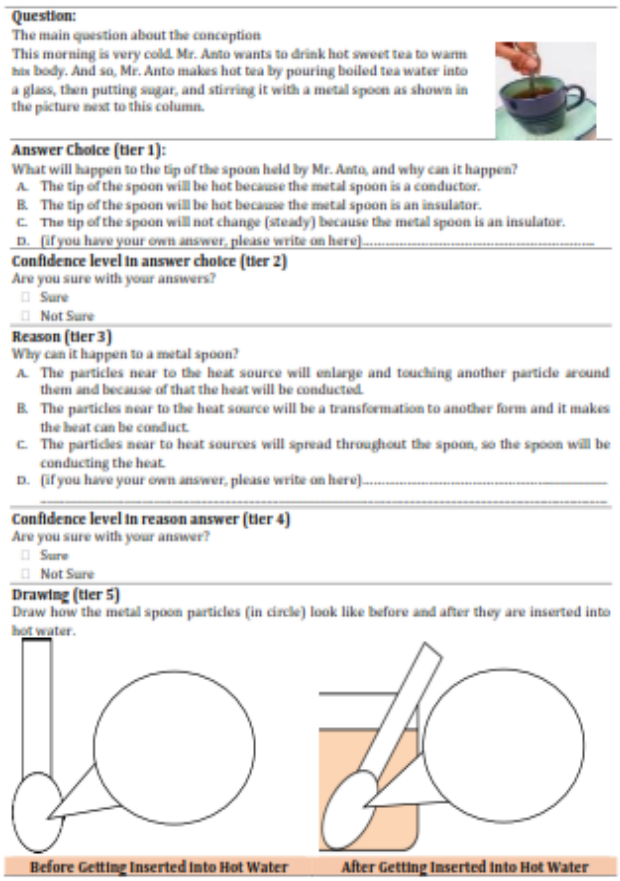

Figure 2. Five-tier multiple-choice sample with drawings or conclusions (source: Anam, 2019)

The use of instruments to provide pictures or conclusions in identifying misconceptions in students. With this additional instrument, it can provide insight into the development of children's representations, provide reflections on what students think about the content presented and learned, and train students' critical thinking skills (Anam, 2019). In addition, by providing pictures and conclusions, the teacher understands the level of mastery of students' concepts more deeply.

Meanwhile, the use of additional instruments with sources of answers is found in Newton's Laws, Static Fluids and Optical Instruments. As an example of the use of the five-level multiple-choice instrument conducted by Rosita (2020).

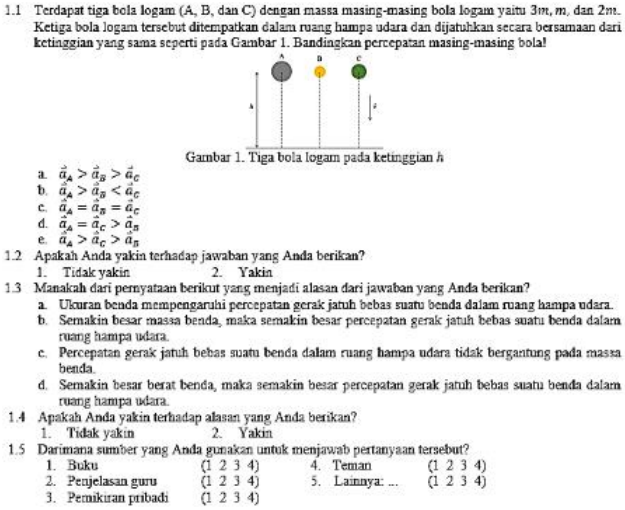

Figure 3. Five-tier multiple-choice sample with source answers (source: Rosita, 2020)

In this study, it was found that the causes of students' misconceptions can be sourced from books, teacher explanations, personal thoughts, and study friends. With this additional instrument, it can show the intensity of students in using information sources in answering questions. So, by using this instrument the teacher can find solutions to misconceptions that arise in learning.

Discussion

Diagnostic test instruments in educational research with the aim of knowing students' mastery of concepts can be in the form of interviews, open-ended questions, and multiple choice. In multiple-choice there are various types including simple multiple-choice, two-level multiple-choice, three-level multiple-choice, four-level multiple-choice, and even five-level multiple-choice. In this discussion, we describe the newest and most frequently used instruments, namely four-level multiple-choice and five-level multiple-choice.

1. Four-Tier Multiple Choice

The four-tier multiple-choice test is a refinement of the three-tier multiple-choice test. Sequentially, the first-tier multiple-choice tests are regular multiple-choice tests with distracting answers; a two-tier multiple-choice test asks students to give their level of confidence in answering the questions given; A three-tier multiple-choice test asks students to give reasons for answering questions at the first level; and a four-tier

multiple-choice test asks students to provide a level of confidence in stating their reasons for answering questions at the third level (Anam, 2019; Kaltakci-Gurel et al, 2017). The four-tier multiple-choice test can reveal students' mastery of concepts, measure students' understanding and identify students' misconceptions. In addition, Guswina, (2020) said that four-level multiple-choice can correctly assess students' misconceptions compared to two-level multiple-choice and three-level multiple-choice instruments

Assessment using multiple-choice four high provides information on the level of student understanding that is clearer for educators to a concept of subject matter. The level of student understanding obtained from the four-tier test in the form of students understanding the concept, lack of knowledge, False negative, false positive; and misconceptions can be seen in Table 4.

Table 4. Combined Four-tier test answers

No	Answer Combination				Category
	First Level	Second Level	Third Level	Fourth Level	
1	Right	Sure	Right	Sure	SC
2	Right	Sure	Right	Not	LK
3	Right	Not	Right	Sure	LK
4	Right	Not	Right	Not	LK
5	Right	Sure	wrong	Sure	FP
6	Right	Sure	wrong	Not	LK
7	Right	Not	wrong	Sure	LK
8	Right	Not	wrong	Not	LK
9	wrong	Sure	Right	Sure	FN
10	wrong	Sure	Right	Not	LK
11	wrong	Not	Right	Sure	LK
12	wrong	Not	Right	Not	LK
13	wrong	Sure	wrong	Sure	MSC
14	wrong	Sure	wrong	Not	LK
15	wrong	Not	wrong	Sure	LK
16	wrong	Not	wrong	Not	LK

Information: SC: Understand Concepts; FN: False negative; FP: False Positive; LK: Lack of Knowledge; MSC: Misconception, Source: (Putra, 2020; Gurel, et al., 2015)

In research using a four-level multiple choice test conducted by Fenditasari, (2020) and Jannah (2020) added that the misconceptions that occur can be categorized into five things, namely preconceptions, intuition, wrong reasoning, humanistic thinking, associative thinking. According to Suparno, (in Paramitha, 2021) the source of misconceptions that arise in students can be caused by the students themselves, teachers, textbooks and learning methods. However, in contrast to the research conducted by Hasran, (2021) after knowing the students' misconceptions, the researchers conducted interviews with students to uncover the causes of misconceptions.

2. *Five-Tier multiple Choice*

Based on the lack of information contained in the four-level multiple-choice to multiply students' conceptual mastery, additional instruments are needed in the multilevel multiple-choice test. Based on the needs of the fifth instrument at five-level multiple-choice, it can be in the form of providing an explanation of the concepts students have in the form of pictures or giving conclusions about the concepts and sources used by students in answering first and third-level questions.

The use of the instrument in the form of an explanation picture or conclusion at the fifth level provides an assessment in the form of scientific drawings (conclusions), unscientific drawings (conclusion), misconceptions of drawing (conclusions), undefined pictures (conclusions), and no drawings (conclusions). The evaluation criteria for drawing (conclusions) can be stated in Table.

Table 5. Categories of answers to students' drawings or conclusions

Category	Explanation
Scientific Drawing (Conclusion) (SD/C)	Respondents provide an overview or conclusion based on actual scientific concepts.
Partial Drawing (Conclusion) (PD/C)	The response provides an overview or conclusion that is almost close to the scientific conception with a slight deficiency in the description or conclusion.
Misconception Drawing (Conclusion) (MD/C)	Respondents gave a picture or conclusion that was inaccurate or different from the scientific conception, but they drew and concluded at the submicroscopic level.
Undefined Drawing (Conclusion) (UD/C)	Respondents provide a description or conclusion that is not understood, even though the description or conclusion given is at the submicroscopic level.
No Drawing (Conclusion) (ND/C)	Respondents did not provide an overview or conclusion at all or only wrote down their answers.

The use of five-level multiple-choice provides more information than four-level multiple-choice. Thus, the five-level multiple choice diagnostic test can identify students' deeper conceptual understanding. The table below summarizes the various answers students gave and the student's concept categories on the five-level diagnostic test

Table 6. Five-level Answer Categories and Level of Concept Understanding.

NO	Answer Combination					
	First Level	Second Level	Third Level	Fourth Level	Fifth Level	Category
1	Right	Sure	Right	Sure	SD/C PD/C UD/C MD/C ND/C	SC ASC LK LK UnC
2	Right	Sure	Right	Not		
3	Right	Not	Right	Sure		
4	Right	Not	Right	Not		
5	Right	Sure	wrong	Sure		
6	Right	Sure	wrong	Not	PD/C or	
7	Right	Not	wrong	Sure	UD/C or	LK
8	Right	Not	wrong	Not	MD/C	
9	wrong	Sure	Right	Sure		
10	wrong	Sure	Right	Not		
11	wrong	Not	Right	Sure		
12	wrong	Not	Right	Not		
13	wrong	Sure	wrong	Not	PD/C or	
14	wrong	Not	wrong	Sure	UD/C or	NU
15	wrong	Not	wrong	Not	MD/C	
16	wrong	Sure	wrong	Sure	PD/C or UD/C or MD/C	MSC

Information:
SC: Understand Concepts; LK: Lack of Knowledge; ASC: Almost Scientific Conception; NU: Don't Understand the Concept; MSC: Misconceptions; UnC: Uncode Sources (Fajriyyah, 2020; Putra, 2020; Anam, 2019)

Based on the findings of the research conducted by Putri (2021); that in addition to identifying misconceptions in students, the five-level multiple-choice test shows the level or level of concepts possessed by students. In addition, five-level multiple-choice can provide insight into children's representational development, provide an overview of the concepts that students understand, and bring students to higher-order thinking when working at the conceptual level (Anam, 2019). Therefore, we should not underestimate the concepts that students have. It could be that students lack confidence in answering questions or they do not understand the meaning of the question.

At this stage, the researcher will present Table 7. differences in four-level and five-level diagnostic tests.

Table 7. Difference between four-level and five-level diagnostic tests.

Point	Four-Tier Multiple Choice	Five-Tier Multiple Choice
Ability to diagnose misconceptions	Provide more explanation in identifying misconceptions in students.	Provide more explanations in identifying students' misconceptions and knowing the level of understanding of the concepts possessed by students. Because it is reinforced by giving pictures or representations from students
Multiple choice	Students provide answers and reasons for answers as well as the level of confidence in the answers and reasons for answers	In addition to students providing answers and reasons for the answers as well as the level of confidence in the answers and reasons for the answers, students are given the opportunity to provide the concepts they have and the sources used in choosing answers.
Result category	SC: Understand Concepts; FN: False negative; FP: False Positive; LK: Lack of Knowledge; MSC: Misconception	SC: Understand Concepts; LK: Lack of Knowledge; ASC: Almost Scientific Conception; NU: Don't Understand the Concept; MSC: Misconceptions; UnC: Uncode
Causes of Misconception	Cannot find out the cause of misconceptions without additional instruments such as interviews	Able to determine the causes of misconceptions

Modification: Anam, (2019)

Conclusion

The use of four-level and five-level multiple-choice diagnostic tests can identify conceptual misconceptions that students have, especially in physics lessons. In addition, diagnostic tests are able to diagnose deeper levels of student understanding and identify the causes of misconceptions in students. Namely with a five-level multiple-choice instrument. A five-level test provides a clearer and deeper explanation of students' misconceptions. One of the advantages of five levels with other multiple-choice questions is that students can express their opinions or ideas both in the form of pictures and conclusions. Thus, a teacher gets more information about the concepts that have and have not been mastered by students. In addition, the five-level multiple-choice test can also combine multiple-choice questions with the sources students use in answering multiple-choice questions so that teachers can take action and prevent the spread of misconceptions.

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