



The Advantages of Diagnostic Tests for High School Students in Physics Learning: A Literature Review

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Abstract. During the learning process, especially in physics, students experience many difficulties solving a problem. The difficulties will lead to misconceptions about learning indicators experienced by students. It will cause students to have trouble understanding the following material because one concept and another are interconnected and have a hierarchical relationship in studying physics. Therefore, it is necessary to identify students' misconceptions. One of the ways to identify students' misconceptions is using a diagnostic test. In this paper, the author discusses the extent of the advantages of diagnostic tests for high school students in learning physics to identify students' misconceptions.

Keywords: Diagnostic test · misconception · physics learning

1 Introduction

Learning is the process of student interaction with educators, materials, learning methods, or the provision of materials, learning strategies, and learning resources in a learning environment [1]. Therefore, the Law on the National Education System states that learning is a process of interaction between students and educators and learning resources in a learning environment. (Indonesian Law No. 20 of 2003, Article 1). In particular, in physics subjects, learning physics is essential in shaping students' mindsets to become quality human beings. Therefore, understanding the concept of physics is also very important in learning physics because by mastering the concept of knowledge, students will remember the material being taught longer [2]. However, in the teaching and learning process, many students still think physics is a complex subject [3]. In addition, it was found that student's ability to solve complex problems was low [4]. Based on a research questionnaire conducted by Rismatul, 33% of students said that physics was a challenging subject. For various reasons, 51% of students said that physics subjects were difficult to understand [4]. It causes students to find it challenging to understand physics lessons because, according to students, physics subjects contain too many equations and concepts. The learning is not fun and is too fast for students to follow. On the other hand, students say physics is fun and challenging because they feel it is present in everyday life.

However, according to Gabel, [5] observing physics in everyday life can also be a factor in the existence of misconceptions for students because sometimes, through observations, students' feelings can deceive them in understanding the phenomenon. Misconceptions are students' conceptions that do not match the scientists' conceptions [6]. The concept is Generally built on common sense or intuition to make sense of the world in everyday experience, it is only a practical description of the world of reality [7]. The causes of students' misconceptions are very diverse and closely related to the research results by Rismatul [4], which are caused by learning concepts that are not accessible to students' mental development. In addition, the causes of student misconceptions can also be caused by errors in initial preconceptions, abilities, interests, ways of thinking, and students' friends, then the teacher's inability, lack of mastery of materials and learning methods as well as teacher attitudes that are not good and can also be caused by culture or language that used in learning [8] also sometimes understand the primary physics material taught by the teacher but cannot interpret it correctly, giving rise to a misconception [9]. Based on these various things, we know that this misconception occurs because of mistakes made by someone in constructing a conception based on information about the physical environment and its surroundings or accepted theory. Misconceptions can be identified through the relationship between two concepts, whether true or not. Usually, misconceptions can be seen in false propositions and the complete absence of relationships between concepts.

This misconception will undoubtedly hinder the teaching and learning process [3]. Especially in physics learning, one concept and another in the following material have a hierarchical relationship [10]. So if, at the beginning of the material, students have experienced misconceptions, their understanding of the following material will be different, and they will find it difficult to accept the following material. Thus, the teacher must identify the extent to which students understand the physics material that has been taught.

To identify students' understanding of an existing basic competency, the teacher can use concept maps, written tests, clinical interviews, and in-class discussions or conduct a diagnostic test assessment [5]. This diagnostic test is used to discover students' learning difficulties, including misconceptions in understanding concepts [6, 11]. There are several diagnostic tools that can be used, namely interviews, open-ended questions, concept maps, and test instruments in the form of a description test or two-tier multiple choice [12]. Diagnostic tests are carried out when information is obtained that some students fail to participate in the teaching and learning process in the previous subject, and in this context is the subject of physics. Therefore, the author's hypothesis, the use of diagnostic tests for high school students in physics learning, is that this test is very effective in determining the extent of students' understanding of the material so that teachers can decide what steps should be taken to avoid misconceptions in students.

2 Method

In this study, the author uses the literature review method. According to Synder (2019), in literature review, there are several types of review methods, such as some types of literature that have strict requirements for strategies and select articles to be included in

the search. They effectively synthesize what is shown by a collection of studies in a particular question. The systematic literature review can be described as a research method and process to identify and critically assess relevant research and collect and analyze data from that research [13]. There is also a semi-systematic library designed for topics that have been conceptualized and studied by various researchers in various disciplines and which build on a fully systematic process [13, 14], as well as an integrative library used to combine multiple research articles. Or various perspectives to get a new theory [13]. Based on these criteria, the authors used a systematic review method to compile the advantages of administering a diagnostic test to identify students' misconceptions.

The stages of this research are written based on the Eight Step Guide to Conducting a Systematic Literature Review [15]. The study began by identifying the purpose of making this paper, namely to determine the advantages of administering a test to identify students' misconceptions in learning physics in high school. After knowing the purpose, the writer decided to form a team with lecturers to support the research being conducted. After that, the writer chose to review the advantages and disadvantages of each type of diagnostic test to compare the most effective tests in identifying misconceptions in students. After that, the author looks for references from research journals and books related to the topic of cognitive diagnostic tests. After finding various references that support the chosen topic, the author extracts the information needed to write this literature review. Not all data is included in this paper from the various information obtained. To maintain the quality of this paper, we need to assess the quality of the paper obtained as reference material. After getting the information needed with good quality, the authors synthesize and analyze the references. So, we can find out the explanation of each type of diagnostic test, its advantages and disadvantages, and compare each type to find out which type is the most ideal for identifying high school students' misconceptions in learning physics.

3 Discussion

Indonesia's education system demands assessments from various aspects possessed by students, such as cognitive, psychomotor, and affective aspects [16]. This assessment measures how far students' abilities in different aspects are across multiple learning indicators [17]. In terms of cognitive aspects, the occurrence of misconceptions in students can cause an obstacle in the acceptance of learning materials [3, 10, 18]. In identifying the misconceptions experienced by students in a study group at a school, the teacher can conduct an assessment that determines multiple choice that can be used effectively and efficiently on test takers whose numbers tend to be significant [17, 19, 20]. These diagnostic tests also vary. Namely, there are one-tier, two-tier, three-tier, and four-tier diagnostic tests [21].

One-tier diagnostic test is a multiple choice test to determine whether students understand the concepts that are true or false. The data obtained from this one-tier diagnostic test is only limited to the truth or error of student answers [22] This diagnostic test can be in the form of a multiple choice test. For a large research sample, multiple-choice tests are the best alternative for diagnosing misconceptions about a problem [23].

The two-tier diagnostic test is a diagnostic test that has two tier questions. The first tier contains conceptual questions as multiple-choice questions, and the second tier includes

alternative reasons for each answer to the questions in the first tier [19]. In this two-tier diagnostic test, the answer is correct (students can understand the concept) if both tiers are answered correctly [24]. However, based on the findings in this study using two-tier diagnostic questions, there is a weakness, namely, finding out the cause of the difficulties experienced by students in doing the test (both types of misconceptions and patterns of errors) is still not enough. Hence, it is still necessary to conduct interviews with several students [6]. Categorization of the classification of answers to the two-tier instrument that has been done by students, the category of student answers can be seen in Table 1.

In research conducted by Ariska regarding the level of the understanding for study of students in astrophysics courses, data on the percentage of categories of concept understanding levels, both students who understand the concept, experience misconceptions, or do not understand the concept, are shown in Table 2. Table 2 is an example of the results or outputs of administering diagnostic tests to students in the form of categories study student of understanding levels of each question critical representing various learning indicators. The one-tier, two-tier, three-tier to four-tier diagnostic tests have the same output, namely the variety of students' levels of understanding. So that educators can find out the extent of student understanding and how many students are included in each of these categories.

Figure 1 shows the results of the percentage level of student understanding of each item. As in the first item, 90.9% of students understand the concept in that item which

Table 1. Criteria for students' concept understanding of two-tier instruments [25]

Category	Answer	Reason
Understand Concept	Right	Right
Misconception	Right	Wrong
Misconception	Wrong	Wrong
Do not understand	Wrong	Wrong

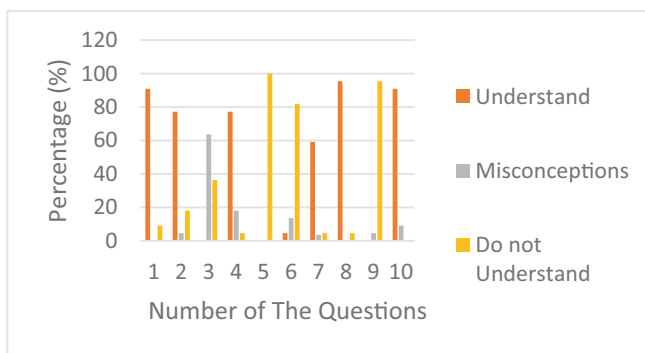


Fig. 1. Student Two-Tier Diagnostic Test Results Data [25]

discusses the concept of a solar eclipse, and there are no students who have misconceptions. 9.09% of students do not understand the concept of a solar eclipse. The same goes for the following questions [25].

Meanwhile, the three-tier diagnostic test continues the two-tier diagnostic test. In the three-tier diagnostic test; the first tier contains multiple-choice conceptual questions, the second tier includes answer choices regarding reasons, and the third tier is a question about the students' confidence scale in answering the two questions above (both conceptual questions and the reasons for the answers) or what is called CRI (Continuity Response of Indexes) [22, 24].

In the three-tier diagnostic test, to analyze the level of student answers, the criteria for understanding the concepts presented in the table can be used to analyze students' answer levels [18]. Through this analysis, the teacher or instructor can find out what students have not understood in subjects.

This three-tier diagnostic test is the most effective diagnostic test to reduce the habit of students who answer only by guessing [22]. In addition, this three-tier diagnostic test also helps researchers understand the selection of students' answers based only on guesses or on their understanding of concepts [27].

Then there are the four-tier diagnostic tests. The four-tier diagnostic test is a test used to identify students' misconceptions, which consists of four tier, which is a continuation This is because the 4-point diagnostic test provides a certain degree of confidence in the reasons students chose. To facilitate comprehension of the content of this four-step diagnostic test level, the first step includes multiple-choice questions, the second step includes the student's confidence in choosing an answer option, and the The second stage has a choice of reasons., and the fourth tier contains confidence in choosing that reason [20].

In the four-tier diagnostic test, to analyze the level of student answers, there is a reference table used in diagnosing students' misconceptions on the three-tier diagnostic test [9, 24] (Table 3).

Table 2. Criteria for students' concept understanding level [26]

1 st Tier (Answer)	2 nd Tier (Reason)	3 rd Tier (Confidence Level)	Criteria
Correct	Correct	High	Understand the concept
Correct	Correct	Low	Do Not Understand
	Incorrect		
Incorrect	Correct	High	Misconception
	Incorrect		
	Correct		
Incorrect	Correct	Low	Do Not Understand
	Incorrect		

Table 3. Criteria for students' understanding level for 4-tier test [9, 24]

1 st Tier (Answer)	2 nd Tier (Confidence Level Answered)	3 rd Tier (Reason)	4 th Tier (Confidence Level Reason-ed)	Criteria
Correct	High	Correct	High	Under-stand the concept
	High	Correct	Low	Not Under-stand
	High	Incorrect	Low	
	Low	Correct	High	
	Low	Correct	Low	
	Low	Incorrect	Low	
Incorrect	High	Correct	Low	
	High	Incorrect	Low	
	Low	Correct	Low	
	Low	Incorrect	Low	
Correct	High	Incorrect	High	Miscon-ception
	Low	Incorrect	High	
Incorrect	High	Incorrect	High	Error
	Low	Incorrect	High	
	High	Correct	High	
	Low	Correct	High	

Of the four types of diagnostic tests, the difference is in the tier of the question. While the output results obtained after the analysis on each item answered by students are the same, namely in the form of categories of understanding of each student on various learning indicators tested on certain materials.

About the tier of each problem, in the one-tier diagnostic test, only questions or issues related to the completion of the application of teaching materials are used. Two-tier is the same as one tier but added the level of student critical confidence in choosing answers. Meanwhile, the three-tier diagnostic test is a continuation of the two-tier diagnostic test, in which the contents of the tier are added regarding the reasons for choosing the answer in the first tier. The last one, at the four-tier, is also a continuation of the three-tier diagnostic test, with an additional level of student learning confidence in choosing reasons. Each diagnostic test has its advantages and disadvantages that can be used to prepare diagnostic test questions and administer a diagnostic test for students' misconceptions (Table 4).

Given the advantages of each of these types of diagnostic tests, their use in the evaluation process in schools is also diverse. In general, we can know that the existence of a three-tier diagnostic test is a form of refinement of the two-tier diagnostic test. Likewise, the four-tier diagnostic test is a refinement of the three-tier diagnostic test.

Table 4. Advantages and disadvantages of type of diagnostic test

Type Of Diagnostic Test	Advantages	Disadvantage
Two-tier	<ol style="list-style-type: none"> 1. The amount of material that can be asked for is relatively large compared to the material covered in the form of a description [28]. 2. Can measure the level of higher-order thinking skills (analysis, evaluation, creation), which are generally difficult to do with ordinary multiple choice questions [28] 3. Easy, fast, and objective scoring [28] 4. Can be used as a diagnostic tool for students' material understanding [28] 5. It Can be used to determine the effectiveness of the teacher's learning [28] 6. There are fewer opportunities to guess or shoot answers because the first-tier questions and second-tier questions are interrelated and there is a CRI scale that shows students' confidence in the selected answers [28] 	<ol style="list-style-type: none"> 1. Less can be used to measure verbal ability [28]. 2. Preparation of good questions requires a relatively long time compared to other forms of questions [28]. 3. Students are not used to using questions in the form of two-tier multiple choice questions [28] 4. The teacher has never used questions in the form of two-tier multiple choice questions [28] 5. Reference books used by teachers and students in schools have many conceptual errors, so field tests do not get maximum data [28].
Three-tier	<ol style="list-style-type: none"> 1. Three-tier diagnostic tests are more valid in finding students' conceptions and misconceptions than one- or two-tier tests [27] 2. Three-tier test uses a simple way to determine misconceptions and distinguish them from lack of knowledge, namely by adding the level of confidence in the answers and reasons chosen by students for one item at the third level [27]–[30] 	<ol style="list-style-type: none"> 1. Only allows students to choose a single level of confidence in choosing answers and reasons for each item [31, 32]. 2. This single level of confidence cannot detect if students have different levels of confidence in choosing answers and reasons [11, 31] 3. The data processing process for open reasons is less efficient because the teacher has to conduct interviews to synchronize student answers, whether due to experiencing misconceptions or due to ignorance of concepts [11] 4. Three-tier diagnostic test is less accurate in detecting misconceptions. This is caused by the level of confidence in the first and second stages being asked simultaneously [30] 5. The analysis of the combination of answers on the three-tier diagnostic test is still in a broad scope [30, 33, 34]

(continued)

Table 4. (continued)

Type Of Diagnostic Test	Advantages	Disadvantage
Four-tier	<ol style="list-style-type: none"> 1. In the four-tier diagnostic test the level of confidence in the first and second levels is asked separately, so that the analysis of the combination of answers on the four-tier diagnostic test is more specific or clearer than in the tree-tier diagnostic test [30] 2. The teacher can distinguish the level of confidence in the answers and the level of confidence in the reasons chosen by students so that they can dig deeper into the strength of students' understanding [11] 3. Teachers can diagnose misconceptions experienced by students more deeply [11] 4. The teacher can determine the parts of the material that require more emphasis [11] 5. Assisting teachers in planning better learning to help reduce students' misconceptions [11] 	<ol style="list-style-type: none"> 1. It Cannot be used to look at the achievements of students and the possibility of students' choices in answering questions at the first tier can affect the choice of answers at the tier of reason answers [30]

However, until now, both three-tier and two-tier diagnostic tests are still used in the class evaluation process with some consideration of the advantages of each type of diagnostic test.

Based on the description of the advantages and disadvantages of each type of diagnostic test and its use in identifying students' misconceptions, it can be seen that the use of the four-tier diagnostic test is the right choice because through this four-tier diagnostic test it can identify students' misconceptions on each learning indicator that stated in each question more carefully [11]. Therefore, this proposed research will develop an objective test in the form of multiple choice with three choices then made four-tier (4-tier) [37].

Through the diagnostic tests conducted by the teacher, it is proven that the teacher can analyze the extent to which students' ability to understand various indicators is presented through the items of the diagnostic test. Based on data analysis, it can also be obtained the following graph (Fig. 2).

The chart is an example of an analysis of students' misconceptions using a three-tier diagnostic test conducted by Asmin [18]. Based on the chart, we can observe that in each learning indicator contained in each item, it can be analyzed how many students have misconceptions, understand the concept, or do not understand the concept that has been taught. The diagnostic test in Asmin's research was carried out to measure students' understanding of the material of temperature and heat, where it was concluded that in the matter of temperature, 69% of students still had misconceptions. On the heat material, as many as 63.7% of students experience misconceptions, and their understanding of

Table 5. Application of each diagnostic test’s type

Type of Diagnostic Test	Application of Each Diagnostic Test’s Type
Two-tier Test	Used when the teacher wants to evaluate students, with the advantage of using this type of diagnostic test is that the assessment of the questions is more straightforward, faster, and objective & the reason for choosing the answer at the second tier can reduce the chance of selecting the answer [28]. But if it is used to diagnose students’ misconceptions, this test does not get satisfactory results [35]
Three-tier Test	The three-tier test is used when the teacher wants to further identify students’ misconceptions, mainly because this three-tier diagnostic test complements the shortcomings of the two-tier test by increasing the confidence level [31]. In this diagnostic test, the teacher can determine whether students understand the concept, do not understand the concept, or experience misconceptions [31, 36]
Fout-tier Test	This test complements the three-tier diagnostic test by separating questions about the students’ level of confidence from the contextual questions’ answers with the level of confidence in the students’ reasons [30, 31]. This helps the teacher to get the results of the identification of misconceptions more thoroughly and get convincing results. [30]

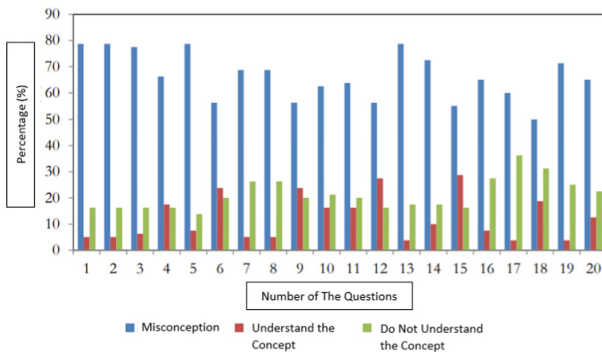


Fig. 2. Three-Tier Diagnostic Test Results Chart [18]

this material is only around 12.3%. The grouping of students’ level of misconceptions is presented in Table 5 (Table 6).

So it can be concluded that from the data shown in the graph, the percentage of student’s misconceptions is high. So, there is a need for a re-examination of the learning that has been taking place so far, including aspects of teachers, learning media, learning models, learning environments, and others.

Based on research results from testing diagnostic questions from one-tier to four-tier, the four-tier diagnostic test instrument can be said to be the most effective [39]. Let’s see an example of a question from the four-tier test that is more effective (Table 7).

Table 6. Student misconception category level [38]

Percentage of Misconception	Misconception Category
61%–100%	High
31%–60%	Moderate
0%–30%	Low

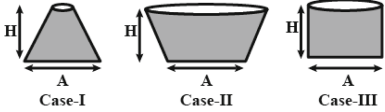
As in the example of the problem in the four-tier test, we can see that it is the most complete diagnostic test because it consists of 4 stages in analyzing student misconceptions in detail. There are also more criteria than other types of diagnostic tests in determining students' level of understanding, whether students understand the topic, do not understand the topic, or there is a misconception or lack of concept. Because of the many criteria, it will be more valid or credible, the results of the analysis on student understanding.

As in the results of the four-tier diagnostic test that was carried out on class X students of SMA Muhammadiyah 1 Palembang regarding the material of straight motion (Fig. 3).

Based on the analysis of the results of understanding the concept, as many as 37.1% experienced misconceptions about the material. In comparison, 43.8% did not understand the concepts being taught, and only 13.5% of the sample students understood the concept of straight-motion learning. Of course, the number of students who experience this misconception is due to the lack of development of their knowledge about the subject [40]. By implementing this diagnostic test, the teacher can also find the percentage of misconceptions for each indicator of the straight-motion material.

So that after the teacher carries out the analysis, she can quickly determine what steps to take so that the majority of students understand the correct concept in a material. Learning on each of the learning indicators [5]. For example, actions that can be taken afterward are to hold remedial teaching. Remedial teaching can be carried out with various activities, for example, providing additional explanations and examples, changing learning strategies, reviewing past learning, and using variations of learning media that attract students' attention [5].

Table 7. Four tier test's example [37]

Tier 1
 <p>Three containers A, B, and C have different shapes and base widths but the same height. The relation of the fluid pressure experienced by the dots in the container is ...</p> <ol style="list-style-type: none">PB is bigger than PA and bigger than PCPB less than PA less than PCPB is the same as PA the same as PC
Tier 2
Are you sure with your answer in the first tier?
<ol style="list-style-type: none">SureUnsure
Tier 3
What's your reason for answering the question in tier-one?
<ol style="list-style-type: none">If the width of the base section of the container is bigger than the fluid pressure that the dot in the container has experienced will also be bigger but on the other hand, if the base section of the container is smaller, then the fluid pressure that the dot has experienced will also be smaller.If the container volume is bigger then the fluid pressure that the dot inside the container has experienced will also be bigger. But in the other hand, if the volume of the container is smaller then the fluid pressure that the dot has experienced will also be smallerIf the depth of the container is bigger then the fluid pressure that the dot has experienced will also be bigger but on the other handIf the width of the depth inside the container is smaller, then the fluid pressure that the dot has experienced will also be smaller.
Tier 4
Are you sure of your reason for choosing the answer?
<ol style="list-style-type: none">SureUnsure

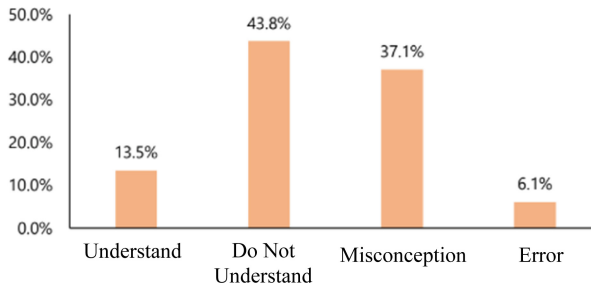


Fig. 3. Percentage of Student Understanding [40]

4 Conclusion

In the use of diagnostic tests, teachers can get the results of students' cognitive tests which can be analyzed in detail to obtain information about the category of student understanding as an indicator of learning in Physics. The results of the analysis obtained by the teacher are the number of students or the percentage of classes in each category of understanding from students who already understand the concept, experience misconceptions, and students who do not understand the concept. So, based on these data, the teacher can determine what attitude should be taken so that the class becomes more effective. Students understand the concept of learning well, mainly cause physics is a material that is formed hierarchically and related to each other. Hence, it is vital to understand the basic concepts before moving on to the following. Based on the results of literature studies from previous studies, the most valid test instrument for analyzing this category of student understanding is the four-tier diagnostic test which has four tier in every question's number to reduce the possibility of students making up answers to each item. However, this four-tier test has a drawback in that it can only detect categories of student understanding without being able to see the cause of students' misconceptions.

Thus, the author's suggestion regarding this research is that teachers or teachers should carry out diagnostic tests regularly so that teachers can know more about the abilities of their students and can determine the proper teaching method so that students can understand physics concepts adequately and appropriately. It is necessary to hold discussions about the results. Tests, especially on items where most students have misconceptions, so teachers also understand the causes of these misconceptions and can be used as evaluation material for future teaching.

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