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Identification of Misconception Using Diagnostic Tests: Systematic Literature Review

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Abstract: This study aims to review studies that use diagnostic tests to identify misconceptions in physics learning and examine the methods used to overcome them. The results of the review can be used by educators in choosing the type of diagnostic test and method to overcome misconceptions. The methods used are PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) and content analysis. A total of 50 articles published in 2018–2023 were analyzed, which focused on the development of diagnostic tests and the application of methods to overcome misconceptions. The results of the study indicate that misconceptions can be identified through various forms of diagnostic tests, such as two-tier, three-tier, four-tier, five-tier, six-tier, and multiple-choice tests. In addition, an educational computing-based approach or computer-assisted learning has proven effective in overcoming misconceptions, especially when supported by the right learning process and model.

Keywords: Diagnostic test; Misconception; Physics; Students

Introduction

Science learning is not only aimed at transferring knowledge and skills but also building students' high-level thinking skills. In developing high-level thinking skills, students need to master the correct conceptual knowledge so that it can be used to solve problems. Conceptual knowledge is obtained from students' knowledge, attitudes, and experiences that continue to develop to learn scientific concepts based on their interactions with the environment that produce an initial understanding of science (Handayani et al., 2018; Hussein et al., 2023; Ozkan et al., 2021; Rannikmäe et al., 2020). The constructivist approach states that learning depends on students' prior knowledge. Students' prior knowledge of science is very important in learning because it can make it easier for students to understand the learning material given by the teacher. However, the prior knowledge possessed by students often experiences misconceptions (Ali, 2019; Chew et al., 2021; Gess-Newsome et al., 2019; Ramdani et al., 2021; Weinstein et al., 2018).

Misconception is a concept held by students or in the minds of students that does not correspond to scientific concepts (Bayuni et al., 2018; Suprapto, 2020; Üce et al., 2019). Students who experience misconceptions are students who are unable to construct experiences that form the basis of their new knowledge. Misconceptions occur in students when they are unable to connect their initial experiences or understanding with new concepts taught during scientific learning. Students who experience misconceptions are certainly very different from students who have no or little knowledge of science. Those who have misconceptions do not realize that the knowledge they have is wrong and contradicts the actual scientific concept. An individual is said to experience misconceptions if the thoughts or knowledge they have contradicts the actual scientific concept, the individual has a strong belief about the wrong concept, and the individual continues to maintain the wrong concept they have.

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Misconceptions are one of the obstacles in the learning process because they can prevent students from obtaining a valid concept about a phenomenon (Chen et al., 2020; Resbiantoro et al., 2022; Soeharto et al., 2019).

Students who experience misconceptions are more difficult to correct than students who do not have knowledge of a material. Misconceptions hinder students in the process of correct conceptual reasoning because students will have difficulty accepting and/or even rejecting insights if the insights do not match or conflict with their understanding. Misconceptions can be caused by various factors including teaching frameworks or teachers who do not master the material, teaching materials or books used have incorrect conceptual delivery and students' prior knowledge which is a determining factor in the formation of the foundation of knowledge built. Aydin (2013) in Marif (2023) said that before teachers deliver lessons, teachers must first recognize and overcome misconceptions held by their students. Teachers must map and identify students' misconceptions where mapping and identifying misconceptions requires a special tool.

Identification of misconceptions in a valid and usable way is an important theme in science education studies. Identification of misconceptions can be done by using diagnostic tests. Diagnostic tests are a complex series of efforts to draw conclusions obtained from the results of examinations, estimates, causes and observations. The function of diagnostic tests is that they can be used to identify misconception problems and can be used to plan solutions to overcome misconceptions that have been identified. Diagnostic tests used can identify learning materials that students have mastered and that are difficult for students to master. The characteristics of diagnostic tests are measuring learning difficulties, developed through source analysis, short answer design, and problem-solving follow-up. Diagnostic tests can be done with several instruments that have been developed by researchers such as open-ended questions, interviews, multiple-choice tests, concept maps, and graded multiple-choice tests. Diagnostic tests developed by researchers have their own advantages and disadvantages from the results of their identification. Therefore, this article will discuss several methods used to identify misconceptions in students.

Although there have been many studies that have raised the topic of identifying misconceptions using diagnostic tests, there are several shortcomings that still need to be studied further. First, there have not been many systematic studies comparing the effectiveness of various forms of diagnostic tests in revealing misconceptions. Second, literature studies that present a comprehensive mapping of diagnostic test approaches in various educational contexts are still limited. Third, most existing researchers only focus on identifying misconceptions without exploring how the results are used to design more effective learning strategies. Therefore, this literature study aims to review and analyze various studies related to identifying misconceptions using diagnostic tests. By mapping the form of the test, instrument characteristics, implementation context, and related findings. This study is expected to contribute to the development of more effective diagnostic test instruments and provide a foundation for learning practices that are more responsive to students' misconceptions.

Method

The research method used in this study is content analysis. The research data presented are also data from previous studies in the field of misconceptions that have been published. The results of this study provide systematic findings from previous studies using diagnostic tests to identify misconceptions so that they are useful for researchers who handle misconceptions. This study uses the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) method. Literature searches from electronic scientific databases were conducted based on the PRISMA method framework guidelines. This procedure is divided into four stages: (1) identification (2) Screening (3) Eligibility (4) Included.

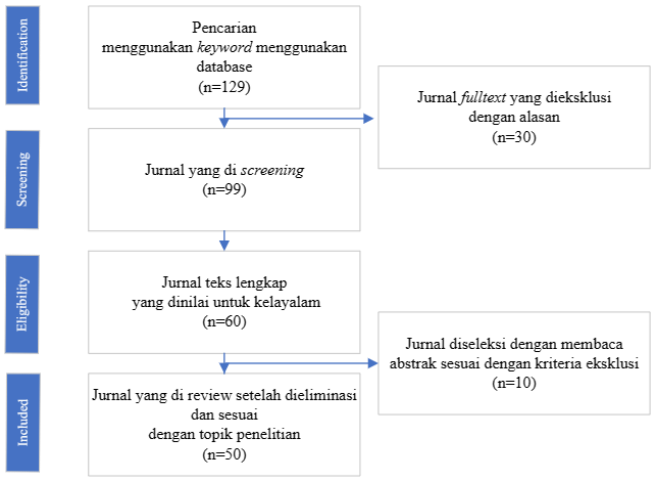

Figure 1. Process article selection

The information presented is the result of a literature review of articles discussing misconceptions and how to identify them in the last five years 2018-2023. Previous studies reviewed were studies that used diagnostic tests to identify misconceptions. Studies aimed at developing tests have been scanned, namely studies that develop tests from scratch and those that adapt existing tests are included in this study. The

databases used in this study come from Scopus and Elsevier. This study began with the identification stage using the keyword misconception diagnostic test as a general topic in the initial search in the electronic database. The next stage is the screening stage by setting boundaries that will be categorized as exclude and include such as the year of publication of the journal, application in the field of physics education, etc. After screening, at the eligibility and included stages the research was carried out by reviewing all journals that were in accordance with the objectives of this study. The results of this study will produce a summary of the review in table 2 in the results and discussion section.

Figure 1 explains that the search on the Scopus database with the keyword misconception resulted in 129 articles which were then screened to produce a final result of 50 articles. The article screening criteria are divided into two, namely inclusion and exclusion for literature studies on misconceptions in the world of education, especially those using diagnostic tests (Jamaludin et al., 2020). The criteria are presented in table 1.

Table 1. Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Relevant Topics Articles should discuss the identification of misconceptions in the context of science education. Using Diagnostic Tests Research should use diagnostic tests as the primary tool to identify misconceptions, for example two tier, three tier, etc. Article Type Articles in the form of scientific journal articles and scientific conference proceedings that are officially published. Publication Year Articles were published in the time frame 2018-2023. Research Quality The article presents clear methodology, scrutinized data, and analyzed results. Level of education Focus on students at formal education level	Not Using Diagnostic Tests Articles that identified misconceptions solely through observation, interviews, or other non-test methods were not included in the criteria. Irrelevant Topics Articles that discuss misconceptions outside the context of formal education or do not explicitly mention misconceptions. Duplication The same article was found in several databases and did not provide any additional information that differed. Incomplete Article Articles that are only available in abstract form or are not fully accessible.

The data analysis technique in this study uses mapping results from the VOSviewer application with calculations.Co-Occurrence. Co-Occurance Analysis maps research topics statistically, where the more frequent the pairing between two keywords, the closer the relationship between the two keywords (Sidik et al., 2024).

Result and Discussion

Types of Diagnostic Tests

This study began by conducting a search on the Scopus electronic database and obtained 129 articles on the topic of identifying misconceptions using diagnostic tests on high school students. The 129 studies that have been reviewed based on the type of publication consist of articles and proceedings and the final results of the total number of articles that match the research theme are 50 articles. Overall, the article aims to identify misconceptions using diagnostic tests. After the search is carried out, it is continued with the identification stage. The identification stage carried out shows that there are various types of diagnostic tests that can be used. The results obtained can be seen in table 1.

Table 2. Types of Diagnostic Tests

Types of Diagnostic Tests	Amount
Two Tier Diagnostic Test	3
Three Tier Diagnostic Test	14
FourTier Diagnostic Test	29
Five Tier Diagnostic Test	1
Six Tier Diagnostic Test	1
Multiple Choice Test	2

Table 1 shows that the majority of articles and proceedings use the four tier diagnostic test type. In addition to the four tier test, articles also use the three tier diagnostic test in identifying misconceptions. Various diagnostic tests that have been developed have been proven to be able to identify misconceptions, but each test has its own advantages and disadvantages. Diagnostic assessment is an important tool for identifying misconceptions and assessing the level of conceptual understanding of students. The instruments used can be conventional multiple-choice tests or more complex forms such as two-tier multiple-choice tests. This two-tier test consists of conceptual questions at the first level and reasons for choosing answers at the second level. Although useful, this instrument has a weakness, namely allowing students to answer

randomly or guess (Myanda et al., 2020; Sıbıç et al., 2022; Soeharto et al., 2022; Zhou et al., 2021).

As a development, a three-tier multiple choice test was used which added a third level in the form of students' confidence in the chosen answer. However, this approach was also not fully effective, because it could not show with certainty at which level students' confidence was located—whether in the answer, the reason, or both. Several studies concluded that two-tier tests were not sufficiently able to differentiate between misconceptions and lack of knowledge, while three-tier tests were still limited by belief variables that had not been specifically identified. To address these limitations, a four-tier multiple choice test was developed. This instrument consists of four levels, namely: (1) conceptual questions, (2) level of confidence in the conceptual answer, (3) reasons for the answer, and (4) level of confidence in the reasons given. This four-tier diagnostic test instrument is considered more accurate and comprehensive in measuring and identifying students' misconceptions and conceptual understanding, compared to the previous two- and three-tier instruments. The statement above shows that the four-tier diagnostic test instrument is considered more effective in identifying misconceptions.

Research related to diagnostic tests in identifying misconceptions is quite a lot, but follow-up of diagnostic results is still rare. Follow-up of diagnostic test results can be in the form of suggestions that can be given directly when students have completed the test. The development of increasingly advanced technology can help in the implementation of diagnostic tests in learning. Diagnostic assessment media is very much needed because it can save time and can help students and teachers to immediately know the results of the tests they have worked on.

In addition to identifying the types of diagnostic tests used, this study also examines the methods used in efforts to overcome misconceptions in physics learning. These methods can be seen in Figure 2.

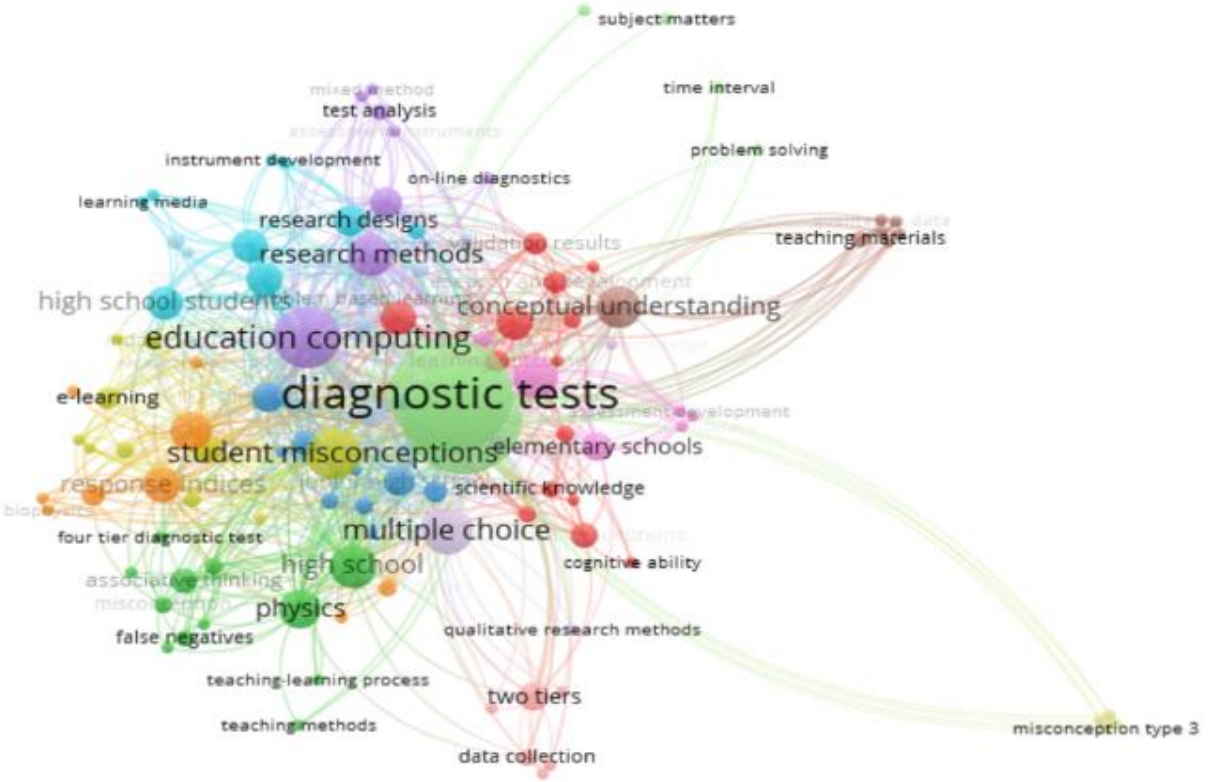

Figure 2. Keywords analysis research design

Figure 2 shows various methods used in an effort to overcome misconceptions from the articles and proceedings reviewed. The method that is widely used is education computing, namely computer-assisted learning. The keyword education computing is interrelated with learning systems and learning models. In an effort to overcome misconceptions, conceptual understanding is needed first, namely a truly in-depth understanding of the concept of the material being studied, especially physics material. In addition, other efforts are conceptual change, namely by changing the wrong concept in students related to the material being studied. Experimental methods are also used to overcome misconceptions because with experiments students can directly observe the physics concepts around them.

Models, methods, and strategies have been widely developed to help overcome misconceptions, but until now misconceptions are still widely found in students. Models that are in accordance with the character of students and the facilities available in schools are greatly needed to be developed. In addition, educators are expected to be able to truly master the concept in order to reduce the level of misconceptions in students.

Conclusion

This study aims to conduct a review of diagnostic test studies in physics learning. A total of 129 articles obtained were then filtered again using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) method, so that 50 articles were obtained that were most relevant to the theme being studied. The articles contain various ways to identify misconceptions, including through two-tier, three-tier, four-tier, five-tier, six-tier diagnostic tests, and multiple-choice tests. In addition, the results of the study also discuss the methods used to overcome misconceptions, such as educational computing, which is computer-assisted learning based on the right learning process and model. The results of this review are expected to be a reference for teachers and researchers in choosing the right diagnostic instruments and developing more effective learning strategies to overcome student misconceptions.

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Author Contributions
This article contributed to the conceptualization of the research idea, methodology, formal analysis, designs, investigation, data analysis and conclusion were written and Formulated by Ditya Lufita. Visualization and management responsibilities and coordination of research planning were carried out by Ficha Aulia Indah Pratiwi and Lucy Triananda while the supervisors were Prof. Heru Kuswanto and Prof. Dr. Dadan Rosana, M.Si.

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Conflicts of Interest
The authors declare no conflicts of interest.

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