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FIVE-TIER FORMAT MISCONCEPTION DIAGNOSTIC INSTRUMENT: SYSTEMATIC LITERATURE REVIEW

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Abstract :
This study aims to identify the types of misconceptions in physics learning and their causes through a systematic literature review. Misconceptions, triggered by internal factors such as incorrect initial understanding and external factors such as inappropriate learning resources, are a major challenge in physics learning. The five-level diagnostic instrument offers an effective solution to comprehensively analyze misconceptions by evaluating students' answers, the reasons behind them, and their beliefs about the answers. A bibliometric analysis of 317 articles (2015–2024) using VOSviewer showed three main themes: students' understanding, diagnostic tool development, and teaching effectiveness. The findings showed that students' misconceptions often occur in abstract physics concepts, such as motion and force. The five-level instrument allows for deeper identification than other instruments, helping teachers to carry out more targeted learning interventions. The results of this study confirm that the use of the five-level diagnostic instrument significantly improves students' understanding of physics concepts and reduces misconceptions. In addition, this study highlights the need to develop more effective diagnostic instruments to support better physics learning processes.

Keywords: Diagnostic Instrument, Five-Tier, Misconceptions, Physics Learning, Systematic Literature Review

INTRODUCTION

Physics is a science that studies nature and its phenomena systematically and logically, involving scientific processes and attitudes to understand topics in physics. Physics is a subject that explains knowledge about the universe and requires continuous training so that thinking power and reasoning ability can develop (Putri, 2021). However, not all students can learn physics well and enjoy this subject. Physics is still considered difficult to understand, thus reducing students' interest and motivation to learn (Setiaji et al., 2023). This difficulty occurs because physics material is known for its complex calculations and formulas. Physics is considered very complex and abstract, because it studies simple things that are then transformed into complex problems with existing calculations. This can cause students to experience misconceptions in learning physics.

Misconceptions in physics learning do not occur without a cause. Misconceptions can be caused by various factors, both internal and external (Budjalemba & Listyani, 2020; Resbiantoro et al., 2022; Rohmah et al., 2023). Internal factors include the desire to learn, inappropriate intuition, wrong initial understanding, and inadequate mastery of concepts (Duda et al., 2020; Songkajorn et al., 2022). While external factors include textbooks used by students and teachers and the learning environment (Carroll et al., 2022; Munna & Kalam, 2021). Misconceptions are also often found in textbooks used by teachers and students, which usually appear in the form of terms, definitions, illustrations, examples, graphs, and their applications (Hamzah et al., 2021; Li et al., 2021; Machová & Ehler, 2023). Misconceptions or misunderstandings refer to concepts that do not correspond to scientific understanding or views recognized by experts in their fields (Maison et al., 2020). Misconceptions can occur in various fields, especially in the field of science which is often considered difficult. This is in accordance with the opinion Astalini et al. (2019) which states that physics as a branch of science is a subject that is less popular with students because of its relatively high level of difficulty. As a result, many students experience misunderstandings in the process of learning physics.

Identifying and addressing misconceptions in physics learning is essential to improving student understanding. Diagnostic tools help detect misconceptions, allowing teachers to adjust teaching strategies and intervene early (Krumphals & Haagen-Schutzenhofer, 2021; Rinjani & Romadona, 2023; Winda & Shofiardin, 2023). They not only identify the type and level of misconceptions, but also provide insight into their causes, such as incorrect prior knowledge or problems in teaching (Miedema et al., 2022). By using appropriate diagnostic tools, such as the five-tier format, teachers can effectively assess students' understanding, measure their confidence in the material, and improve the learning process to prevent misconceptions from becoming permanent incorrect knowledge.

The five-tier diagnostic instrument has the advantage of identifying and analyzing misconceptions in more detail and structure. The five-tier diagnostic instrument includes five levels: content knowledge, confidence in the answer, reasons behind the answer, confidence in the reasons, and students' understanding of the overall level of certainty of the students (Banawi et al., 2022; Salsabila & Ermawati, 2020). This comprehensive five-tier diagnostic test instrument allows for deeper analysis of students' thinking processes, distinguishing between correct answers based on valid reasoning and answers based on guesswork (Haryono et al., 2024). In addition, this instrument also helps in identifying specific misconceptions and understanding their root causes, thus allowing for more targeted and effective learning interventions.

A systematic literature review is important to comprehensively understand the relationship between misconceptions and the use of five-tier diagnostic tests in physics learning. By conducting this review, researchers can identify patterns, findings, and trends in previous studies, thereby providing a clearer picture of the effectiveness of these diagnostic instruments in detecting and addressing students' misconceptions (Ardyan et al., 2023; Sarie et al., 2023). This review also allows to explore the various approaches and methodologies that have been used in previous studies, as well as to reveal potential areas of research that are still under-explored (Du et al., 2023). Thus, this systematic literature review not only contributes to the development of theory, but also provides practical recommendations for educators to improve the physics learning process through a deeper understanding of misconceptions and effective diagnostic strategies (Qian & Lehman, 2017; Resbiantoro et al., 2022).

Previous research conducted by Rokhim et al. (2023) shows the importance of having an appropriate diagnostic instrument to identify misconceptions and multiple representation profiles. However, the study focused more on the chemistry aspect and has not explored in depth the use of similar diagnostic instruments in physics learning which has abstract concept characteristics such as motion and force. The current study attempts to fill this gap by identifying the types of misconceptions in physics learning and their causal factors, both internal and external, through a systematic approach with bibliometric analysis. The five-level diagnostic instrument used in this study not only helps to identify students' misconceptions in depth but also emphasizes the importance of more targeted learning interventions.

The novelty of the current study lies in the application of a five-level diagnostic instrument to identify misconceptions in physics learning, which is different from previous studies that focused more on chemistry learning. This study not only identifies the types of physics misconceptions on abstract concepts such as motion and force, but also analyzes the causal factors, both internal (wrong initial understanding) and external (inappropriate learning resources). The formulation of the problem in this study focuses on the types of common misconceptions that occur in students and the causes of student misconceptions in physics learning. With the increasing attention to the importance of conceptual understanding in physics learning, this study focuses on the relationship between misconceptions and the use of five-tier diagnostic instruments. Through a better understanding of misconceptions and how diagnostic tests can help overcome them, it is hoped that significant improvements can be achieved in the physics learning process, which can ultimately increase students' understanding and interest in this subject. The aim of this study was to identify the types of common misconceptions that occur in students and the causes of student misconceptions in physics learning.

RESEARCH METHOD

This study focuses on the five-tier diagnostic instrument and misconceptions in physics learning. The systematic review was conducted in accordance with the PRISMA guidelines, to conduct and summarize a systematic review, a literature review was conducted systematically from published literature (De Coster et al., 2023; Şalvarlı & Griffiths, 2021; Zainuri & Setiadi, 2023). Therefore, the search method, study selection, quality evaluation, data extraction, analysis, and synthesis process are described in the following sections.

Search Strategy

The most important step in conducting a systematic review is to ensure that all relevant studies can be found accurately. Data were collected from various large databases such as Scopus and Google Scholar, which are related to the research topic. These databases were selected because they contain a large number of publications related to the research topic. Data collection was carried out with the help of a reference manager application, namely Publish or Perish, to obtain articles that are in accordance with the theme being studied (Al Husaeni & Nandiyanto, 2022; Kipper et al., 2020; Rafiq et al., 2023). The search strategy used keywords developed from the main concepts, namely misconceptions and five-tier diagnostic tests in physics learning. The collected data were then stored in *.ris format for further analysis using VOSviewer software.

Article Selection

The selection of articles was based on works published between 2015 and 2024, which were then collected and analyzed. The search criteria focused on titles, keywords, and abstracts that were relevant to the theme of misconceptions, five-tier diagnostic tests and physics learning. Meanwhile, articles that did not meet these criteria were excluded. The selection process involved duplicate screening and abstract review steps.

Quality Assessment

The quality of articles included in the review was evaluated based on the study design, publication source, and impact of the study. The study design was assessed to ensure that each study provided a complete description of the research objectives, methodology used, and results obtained.

Data Extraction

The attributes listed, namely, year of publication, title, details of publication sources, keywords, methodology, and research focus were extracted and analyzed using Vosviewer software. The results of this analysis were then synthesized to answer the research questions.

Data Analysis and Synthesis

The purpose of this study is to construct an attribute map related to misconceptions, five-tier diagnostic tests and physics learning. Bibliometric analysis is applied to evaluate future scientific research opportunities. This study uses metadata from 400 articles, taken from the Scopus and Google Scholar databases. The metadata is evaluated using Vosviewer to build visualizations. This mapping process consists of three types of visualizations, namely network visualization, density visualization, and overlay visualization (Budianto, 2022; Sidabutar et al., 2022).

RESULTS AND DISCUSSION

The results of this study are a summary of 317 included studies, publications conducted between 2015-2024. This study aims to identify the types of misconceptions that commonly occur in students in physics learning and their causes. Based on the literature review conducted, misconceptions are one of the main challenges in physics learning, which are generally caused by various internal factors such as incorrect initial understanding and external factors such as inappropriate learning resources. The results of the study showed that students' misconceptions are closely related to abstract concepts in physics, such as motion, force, and other laws of physics. The five-tier diagnostic instrument developed was able to identify misconceptions more deeply than other diagnostic instruments. This is because the five-tier instrument not only measures students' answers, but also the reasons behind the answers, as well as students' beliefs about the answers and the reasons they choose. The results of the analysis using VOSviewer obtained in this study are as follows:

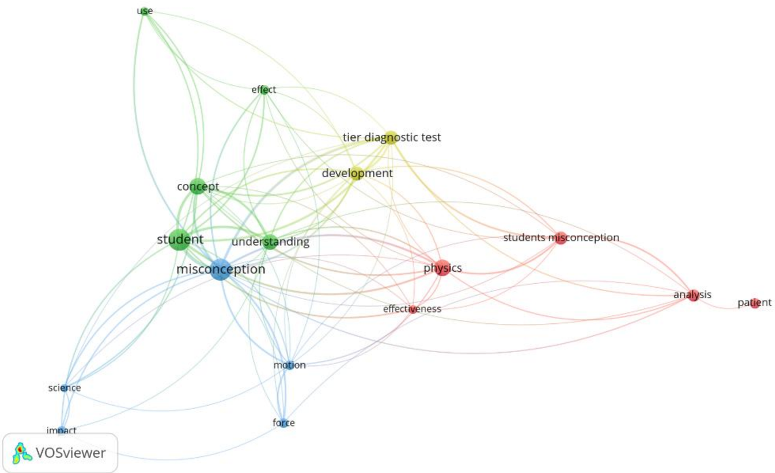

Figure 1. Network Visualization

The figure shows a network visualization generated from an analysis of 317 studies published between 2015 and 2024, using VOSviewer software. The visualization illustrates the relationships between keywords that frequently appear in related studies, grouped into clusters based on their thematic relevance. The colors in the figure represent different clusters, indicating the main themes of the research. The green cluster highlights keywords such as “student,” “concept,” “misconception,” and “understanding,” indicating a focus of research on students’ understanding of specific concepts, particularly those related to misconceptions. This cluster reflects research on how students understand concepts in learning, most likely related to science and physics. The yellow cluster includes terms such as “development,” “tier diagnostic test,” and “effect,” indicating research on the development of diagnostic tools to measure students’ understanding and misconceptions. This cluster refers to efforts to develop tests or instruments to assess students’ understanding in more depth.

The blue cluster focuses on terms such as “science,” “motion,” “force,” and “impact,” indicating that many studies explore basic physics concepts and the impact of students’ misconceptions on their understanding of the topic. Meanwhile, the red cluster highlights terms such as “analysis,” “physics,” and “effectiveness,” which are related to the analysis of teaching effectiveness and diagnostic methods in the context of physics. The studies in this cluster appear to focus on evaluating teaching methods and the effectiveness of diagnostic techniques in addressing student misconceptions. Overall, this visualization provides a sense of how the studies focus on three main themes: student understandings and misconceptions, the development of diagnostic assessment tools, and the analysis of teaching effectiveness, specifically in physics.

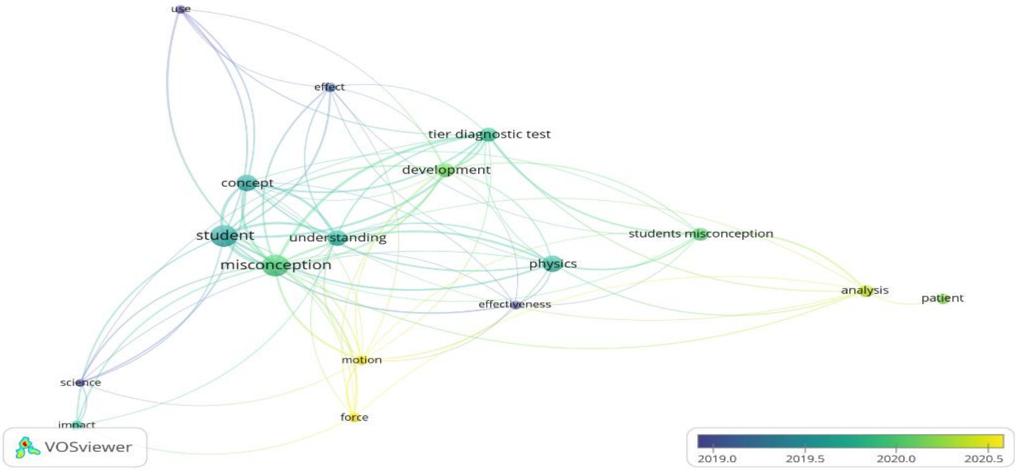

Figure 2. Overlay Visualization

The second figure shows an Overlay Visualization depicting the temporal development of keywords used in related studies, using a spectrum of colors representing the time span from 2019 to 2020. Blue indicates keywords that appeared more frequently in studies conducted in 2019, while yellow indicates keywords that were more dominant in more recent publications, around 2020.5 From this visualization, it can be seen that research in the early period tended to focus on topics such as use, effect, and science, indicating an interest in basic understanding of scientific concepts and their impact on student learning. Over time, research topics shifted to developing diagnostic tools and evaluating the effectiveness of learning methods, with keywords such as development, tier diagnostic test, and students' misconception appearing more frequently in more recent studies. This indicates a shift in research focus towards developing more effective tools for identifying student misconceptions and evaluating teaching approaches. The themes that persisted over time, such as misconception and understanding, indicate that student misconceptions remain a major concern, but approaches to understanding them have evolved to focus more on diagnosing and analyzing the effectiveness of teaching methods.

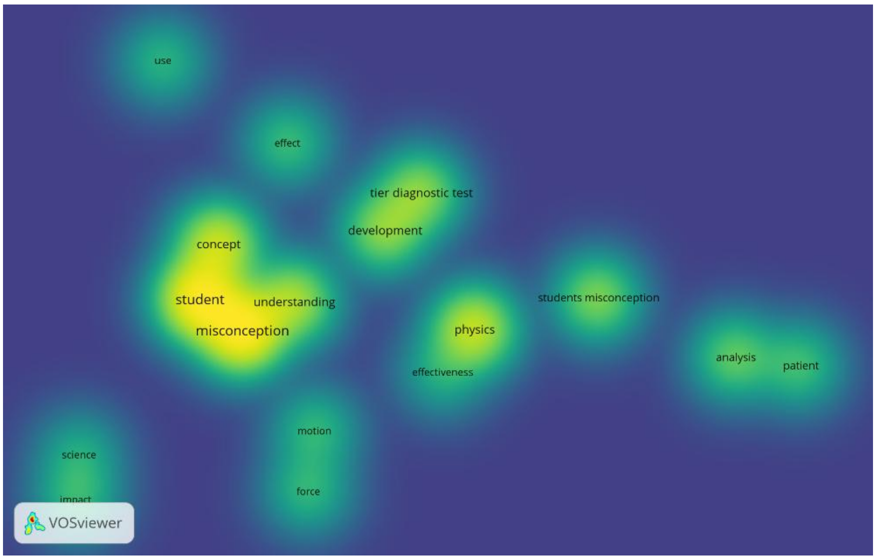

Figure 3. Density Visualization

The third figure shows the Density Visualization showing the density of keyword usage in the analyzed publications. The yellow color indicates areas with high keyword frequency, while the green and blue colors indicate lower frequencies. From this visualization, it can be seen that keywords such as student, misconception, concept, and understanding are in the areas with the highest density, indicating the main focus of the research on students' understanding, concepts learned, and common misconceptions in the learning process. Other keywords such as tier diagnostic test, development, physics, and students' misconception appear in areas with medium density, indicating that these topics are also important, especially in the context of developing diagnostic tools to measure students' misconceptions in physics. Meanwhile, keywords in areas with low density such as use, effect, science, motion, and force indicate that these topics are not discussed so often in the analyzed literature. Overall, this visualization illustrates that research focuses mainly on students' understanding and their misconceptions, as well as the development of diagnostic tools, with additional attention to physics and teaching effectiveness.

Analysis through VOSviewer illustrates how these misconceptions are divided into several clusters that show the relationship between various physics concepts and students' misconceptions. With network and overlay visualizations, it can be seen that the focus of the study has shifted from simply exploring basic misconceptions to developing more effective diagnostic tools to help teachers understand students' conceptual errors and how to overcome them.

In line with previous research which found that the four-tier diagnostic tool (four-tier test) is often used to detect misconceptions in physics education, but there are several weaknesses, such as the lack of agreement on the criteria for misconceptions and the lack of information on the stages of development of the test tool (Çelikkanlı & Kızılcık, 2022). The current study fills this gap by introducing a five-level diagnostic instrument, which allows for a more in-depth analysis of misconceptions, including students' reasons and beliefs about their answers. Through a systematic and bibliometric approach, the study also identifies internal and external causes of misconceptions and the main abstract physics concepts of focus, such as motion and force (Rafiq et al., 2023). Thus, this study not only addresses the limitations of the four-tier diagnostic tool, but also provides new contributions in supporting more effective learning interventions to reduce misconceptions in physics.

Overall, the use of the five-tier instrument makes a significant contribution to improving the physics learning process. This instrument allows teachers to conduct more targeted interventions based on more detailed identification of misconceptions. Thus, it can be concluded that the development and implementation of this website-based five-tier diagnostic instrument has a positive impact on improving students' understanding of physics concepts and reducing common conceptual errors.

This study presents a novelty through the development of a five-tier diagnostic instrument that is able to analyze students' misconceptions in more depth compared to previous instruments, such as the four-tier test. This instrument not only evaluates students' answers, but also the reasons behind the answers, as well as students' beliefs about the answers and reasons, thus providing a more comprehensive understanding. With the integration of bibliometric analysis and network visualization using VOSviewer, this study also maps research trends related to physics misconceptions and identifies their causes, both internal (such as incorrect initial understanding) and external (such as inappropriate learning resources).

The implications of this study are very broad, ranging from providing teachers with more effective diagnostic tools to design targeted learning interventions, supporting the development of similar instruments in various subjects, to becoming a reference for policy makers in improving the quality of education. Overall, the results of this study provide a significant contribution to the development of physics learning theory and practice by helping to reduce students' misconceptions and improve their understanding of abstract concepts such as motion and force. A limitation of this study lies in the lack of direct testing of the effectiveness of the five-tier diagnostic instrument across a variety of educational contexts and more diverse student populations.

CONCLUSION

This study concluded that the five-tier diagnostic instrument is very effective in identifying and analyzing students' misconceptions in physics learning comprehensively. This instrument not only measures knowledge, but also explores the reasons behind students' answers and the level of student beliefs, allowing for deeper detection of misconceptions. The results of the analysis showed that this instrument excels in helping teachers understand misconceptions and provide appropriate interventions to improve students' understanding. The shift in research focus towards developing more effective diagnostic tools also emphasizes the importance of this instrument in improving the quality of physics learning. Thus, the use of a website-based five-tier instrument contributes significantly to improving students' understanding of physics concepts and reducing misconceptions. Further research is recommended to empirically test the effectiveness of the five-level diagnostic instrument in various educational contexts and other subjects in order to expand its application.

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