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Mapping the Evolution of Tiered Diagnostic Instruments for Identifying Students' Misconceptions in Physics: A Systematic Review of Indonesian Research (2015–2025)

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Abstract – *Misconceptions in physics education are a significant challenge, hindering students' understanding and ability to solve scientific problems. Addressing these misconceptions is essential for enhancing learning outcomes and improving instructional methods. This study seeks to provide a comprehensive analysis of how diagnostic tests have been developed and applied to identify misconceptions in the context of physics education in Indonesia. A Systematic Literature Review methodology was used to analyze 186 scientific articles published between 2015 and 2025, indexed in Google Scholar. The research followed the PRISMA framework to ensure a transparent, replicable process. The findings indicate that diagnostic tests in Indonesia have evolved from simpler two-tier formats to more complex six-tier systems. Among these, the four-tier diagnostic test was the most commonly utilized, proving effective in identifying misconceptions by capturing students' answers, the reasoning behind those answers, and their confidence levels. The review also identified specific topics where misconceptions were most prevalent, including Particle Dynamics, Heat and Temperature, and Vibrations and Waves. These areas showed consistent patterns of misunderstanding across multiple studies. This study underscores the need for continued advancements in diagnostic tools to improve their reliability and validity. It also highlights the importance of exploring less-studied physics topics and expanding the use of multi-tier diagnostic tests. Such efforts are crucial for refining instructional strategies and improving students' conceptual learning in Indonesian physics education. The findings contribute to the field of physics education by offering actionable insights for educators and researchers in designing targeted interventions and advancing conceptual learning.*

Keywords: *diagnostic test; misconceptions; multi-tier instruments; physics education; systematic literature review*

I. INTRODUCTION

The ability to understand physics concepts can be developed through both theoretical learning and their practical application in everyday life, reflecting a strong conceptual understanding (Irawan et al., 2025; Ningsari et al., 2021; Umamah et al., 2024). Physics learning requires a deep understanding of each topic, as the concepts in physics are inherently interconnected and often abstract. For instance, understanding Newton's laws is crucial not only for solving textbook problems but also for analyzing motion in engineering, predicting the trajectory of objects, or understanding safety mechanisms in vehicles. However, mastering these concepts is challenging, especially for novice students (Hajar et al., 2023; Mufti & Sunarti, 2024). The concepts introduced in the early stages serve as the foundation for the development of more advanced knowledge. Since each student possesses a unique level of conceptual understanding in physics, these differences often lead to errors when connecting one concept to another (Simamora et al., 2023).

A concrete example of a common misconception in physics can be found in the concept of acceleration. When asked about the motion of a car moving at high speed and then suddenly braking, approximately 34.48% of students incorrectly believed that the car's acceleration becomes zero at the moment of braking (Triastutik et al., 2021). Difficulties in integrating concepts typically arise from an incomplete understanding, preventing students from linking prior knowledge with new information in a coherent manner. For example, students who do not fully understand the concept of acceleration often struggle to connect it with Newton's Second Law, which in turn hampers their understanding of other physics concepts (Asrida et al., 2024). When students' understanding deviates from scientifically accepted concepts, this condition is referred to as a misconception (Meiliyadi et al., 2024).

Misconceptions in physics can occur at various educational levels, including among secondary school students, university students, and even teachers (Asrida et al., 2024). When educators hold misconceptions, these are often unintentionally passed on to students, perpetuating incorrect scientific understanding and undermining the effectiveness of teaching. This, in turn, negatively impacts students' conceptual development and problem-solving abilities in physics. Misconceptions can be identified through various methods, such as concept mapping, diagnostic tests, interviews, classroom discussions, and practical sessions involving questioning. One of the most effective instruments used to identify misconceptions in physics is the two-tier diagnostic test, as it not only assesses students' final answers but also probes their underlying reasoning, allowing educators to distinguish between a lack of knowledge and deeply held misconceptions (Annisa et al., 2019). Over time, diagnostic test instruments have undergone significant development, evolving from the two-tier diagnostic test to the more complex six-tier diagnostic test (Sekarningtias et al., 2023). The two-tier diagnostic test consists of two levels: the first tier assesses conceptual understanding through multiple-choice questions, while the second tier gauges the student's confidence in their answer (Pratiwi et al., 2024).

Responding to the need for more accurate diagnosis, the three-tier diagnostic test was introduced, adding a third tier that requires students to provide conceptual reasoning for their answers (Solikhah et al., 2025). This was further refined in the four-tier diagnostic test by adding a confidence scale to the conceptual reasoning (Astuti et al., 2021). Subsequent developments led to the Five-Tier Diagnostic Test, which incorporated open-ended or short-answer questions to provide deeper insights into students' thinking (Laila et al., 2024), and ultimately, the six-tier diagnostic test, which integrates all previous tiers and includes an analysis of the sources of students' misconceptions (Utami et al., 2024).

Several previous studies have conducted literature reviews on tiered multiple-choice diagnostic tests, but these reviews have often been limited to specific test types. For instance, Santoso & Setyarsih (2021) reviewed only two-tier diagnostic test, three-tier diagnostic test, and four-tier diagnostic test, while Kasanah & Setiaji (2024) focused solely on four-tier diagnostic test, and Ahzari et al. (2025) included both four-tier diagnostic test and five-tier formats. Sekarningtias et al. (2023) attempted a broader review encompassing two-tier diagnostic test to six-tier diagnostic test, but their study was constrained by a limited dataset and narrow publication year range, failing to provide a comprehensive picture of the evolution of tiered diagnostic instruments, particularly those published in recent years, including 2025. As a result, a systematic and comprehensive literature review mapping the full development of tiered diagnostic tests, from two-tier diagnostic test to six-tier diagnostic test, in the context of physics education in Indonesia remains lacking.

This article aims to fill that gap by presenting a systematic literature review (SLR) that analyzes the development of tiered multiple-choice diagnostic tests for identifying students' misconceptions in physics. This review describes the extent to which diagnostic instruments have been developed and utilized in the Indonesian context. The findings are expected to provide a detailed overview that can inform and inspire future research and practical implementation in efforts to diagnose and address misconceptions in physics learning.

II. METHODS

This study employed a SLR methodology, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework (Rinancy et al., 2024). The PRISMA method was chosen to ensure a transparent, rigorous, and replicable process in identifying, screening, and analyzing relevant literature. The SLR was conducted in a structured and comprehensive manner, involving the identification, analysis, interpretation, and evaluation of relevant studies focused on the topic of interest (Shiddiqi et al., 2024). The PRISMA method, introduced in 2009, is widely recognized as one of the most effective tools for guiding authors in conducting systematic reviews and meta-analyses with proper rigor. Foster, Milner, and Kearney (2015) described the original intent of PRISMA as being to improve the accuracy and completeness of systematic reviews and meta-analyses in the literature. The PRISMA method encourages authors to describe steps taken to minimize bias and maximize accuracy in locating and selecting reports for inclusion, abstracting data, and analyzing the overall intervention effects (Vrabel, 2015). Additionally, it helps in organizing the review structure as a roadmap for researchers (Chaeroni et al., 2024). Using this method, the authors systematically reviewed and identified scientific articles by following a set of clear and structured steps, ensuring comprehensive and rigorous results (Satria et al., 2025).

The PRISMA method involves four key steps: (1) Identification, relevant articles are retrieved from selected databases using defined keywords; (2) Screening, duplicate, and irrelevant studies are removed based on title and abstract; (3) Eligibility, the remaining articles are assessed in full-text against inclusion and exclusion criteria; and (4) Inclusion, the final set of studies is selected for analysis. This structured process ensures that the literature review is systematic, transparent, and focused on the study objectives. Each stage was carefully implemented to ensure that only high-quality and relevant articles were included in the analysis (Arrohmah et al., 2023). High-quality articles were determined based on clear research objectives, the use of valid and reliable diagnostic instruments, appropriate research methods, and the credibility of publication sources, such as peer-reviewed journals indexed in reputable databases. This ensured that the findings of the review were based on robust and trustworthy evidence.

Research Procedure

1. Identification

The identification stage began with a systematic search of both national and international journals through Google Scholar. Google Scholar was chosen over other databases as it is the most comprehensive source (Martin et al., 2021). It also offers more inclusive coverage of Indonesian-language research outputs compared to other databases, which was essential for capturing the development of diagnostic tests within the national context. Moreover, its accessibility and indexing of both local and international sources made it particularly suitable for mapping the comprehensive evolution of tiered diagnostic tests in physics education in Indonesia. The search utilized keywords such as "diagnostic test" and "physics misconceptions" to capture all relevant publications related to the use of diagnostic tests for identifying misconceptions in physics concepts (Latifah et al., 2024). This comprehensive search was intentionally unrestricted by document type or publication year during the initial phase to maximize the breadth of potentially relevant findings. The primary aim at this stage was to compile a broad dataset of documents, which would later be refined through stricter inclusion and exclusion criteria. This step laid a strong foundation for the scope and quality of the literature review, directly influencing the robustness of the subsequent synthesis and analysis phases. In systematic literature reviews, identifying as many previous and relevant studies as possible is crucial to guide the direction and methodology of the current research (Sebastian & Kuswanto, 2024).

2. Screening

In the screening stage, the authors performed data extraction guided by a clearly defined set of inclusion and exclusion criteria, allowing the refinement of data according to the research variables (Syahriannor et al., 2024). The inclusion criteria consisted of articles published between 2015 and 2025, written in either English or Indonesian, focused specifically on the development or application of tiered diagnostic tests (from two-tier to six-tier) in physics education, and indexed in Google Scholar. The exclusion criteria included articles that did not involve physics content, did not address diagnostic test instruments, were not full-text accessible, or were duplicate entries. These criteria ensured that only the most relevant and methodologically sound studies were included in the final analysis. This step involved a meticulous review of the titles and abstracts of the documents identified during the initial search (Fitriyah & Handayani, 2023). The selection was restricted to peer-reviewed journal articles, excluding seminar proceedings, undergraduate theses, or other grey literature. Furthermore, selected articles were required to be relevant to science and education, with a specific emphasis on physics education. The use of inclusion and exclusion criteria helped narrow down the pool of documents to those most relevant and recent in the field (Ghorbiy et al., 2024). Table 1 presents the inclusion and exclusion criteria applied during the screening process.

Table 1. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Diagnostic tests for identifying misconceptions	Diagnostic tests for critical thinking skills
Peer-reviewed journal articles	Seminar proceedings and undergraduate theses
Articles accessible full text	Inaccessible or unavailable articles

3. Eligibility

After the screening process, the remaining articles underwent a detailed assessment of their eligibility. This stage involved a thorough manual review of each article to confirm its direct relevance to the study's focus on trends in diagnostic tests used to identify misconceptions in physics learning. Articles were selected based on their substantive contribution to the topic and thematic alignment with the goals of the review. Eligibility criteria were strictly applied to ensure that only studies explicitly addressing physics misconceptions through diagnostic tests were included, further refining the literature pool for focused and in-depth analysis.

4. Inclusion (Verification)

The final verification stage applied the inclusion criteria rigorously to all eligible studies. The resulting literature dataset consisted exclusively of peer-reviewed journal articles that provided comprehensive discussions on the development and implementation of diagnostic tests for identifying misconceptions in physics education. Each article selected in this phase was considered to have significant insights and implications for the field, directly supporting the objectives of the systematic review.

The article selection process adhered strictly to the PRISMA guidelines, as outlined by Rinancy et al. (2024). The flow of article selection is illustrated in Figure 1.

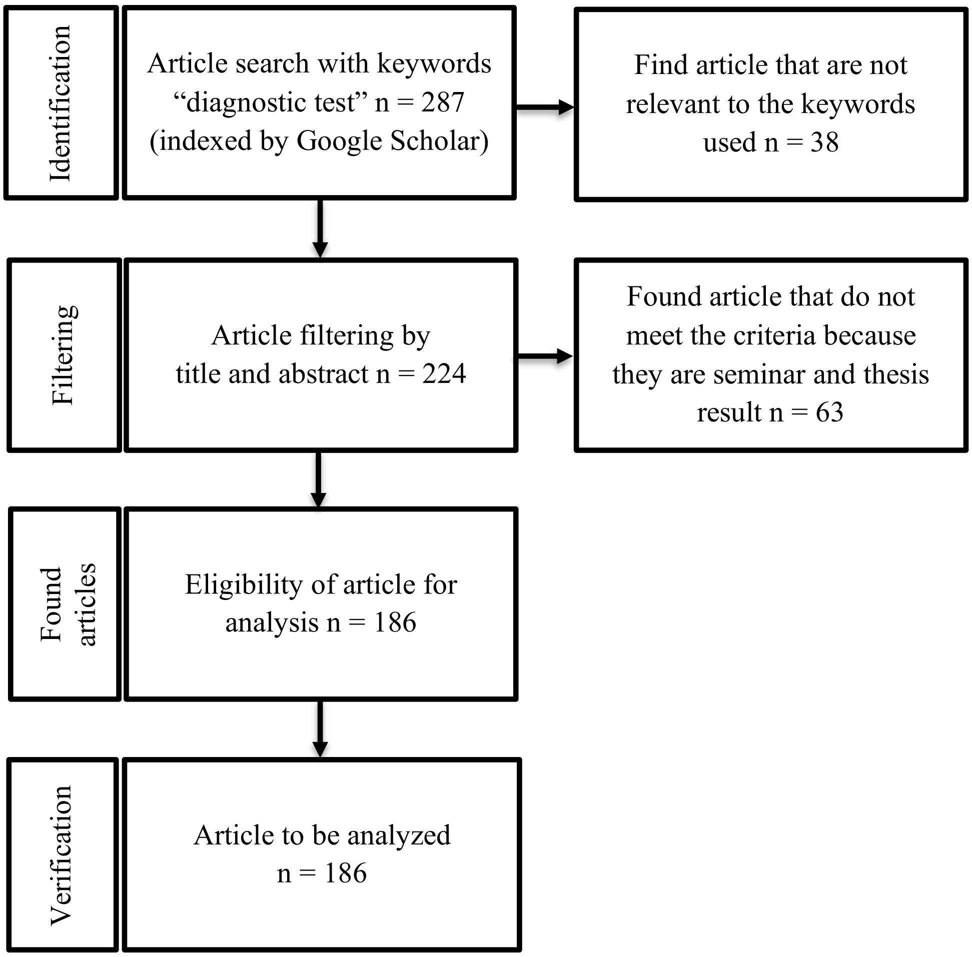

Figure 1. PRISMA flow diagram

Figure 1 illustrates the research flow based on the PRISMA guidelines. Each phase progressively refined the scope of the documents, ensuring that only the most relevant studies were included in the final analysis (Faresta et al., 2024). The identification phase involved a systematic search of scholarly articles using Google Scholar with the keywords "diagnostic test" and "physics misconceptions." This search initially yielded a total of 287 articles. After applying the screening process, 38 articles were excluded due to a lack of relevance to the keywords used. Following this, 224 articles remained after examining the titles and abstracts. Among these, 63 articles were excluded because they consisted of seminar papers and undergraduate theses, which were deemed less methodologically rigorous and unsuitable for further analysis. As a result, 186 articles were selected for in-depth analysis. These articles specifically focused on the use of diagnostic tests to identify misconceptions in physics and were conducted within the Indonesian educational context.

III. RESULTS AND DISCUSSION

The review examined the publication trends of diagnostic test articles in physics from 2015 to 2025, as illustrated in Figure 2. The results revealed a significant increase in the number of studies over time, with a peak in 2024. The growing trend also showed a preference for more advanced tiered diagnostic test formats, particularly the four-tier diagnostic test, reflecting increased efforts to capture students' conceptual understanding with greater depth and accuracy. These trends indicate a growing interest and research activity related to identifying students' misconceptions about various physics topics.

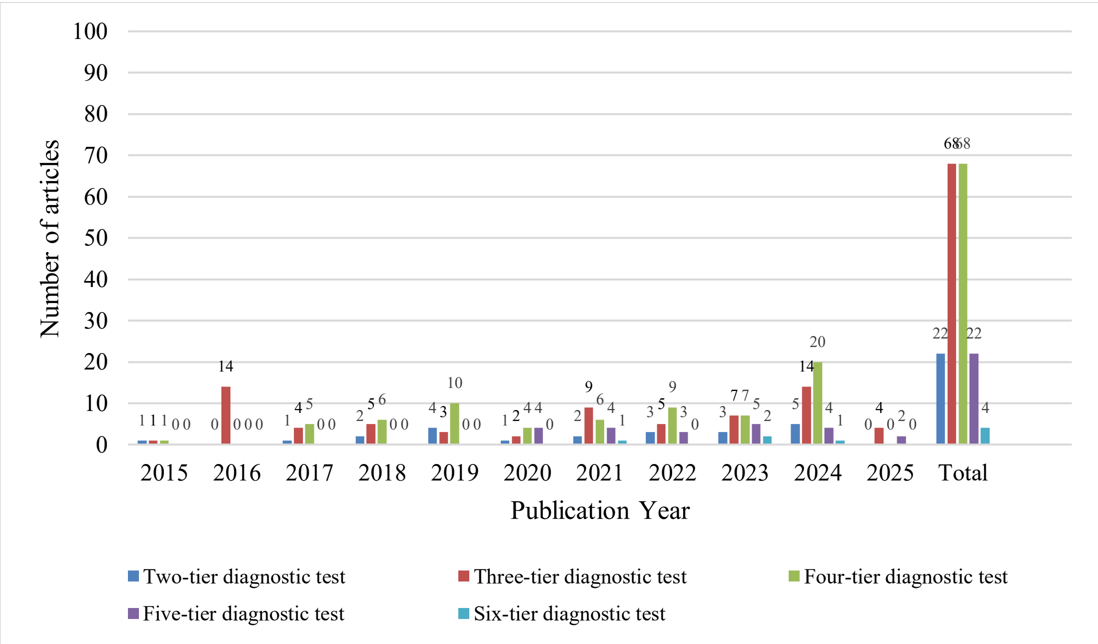

Figure 2. Graph of the number of publications based on year of publication

Figure 2 illustrates the distribution of articles related to the development of diagnostic tests in physics over the period 2015–2025, with a total of 186 articles identified that aligned with the study's focus. Among the various diagnostic assessments, the four-tier diagnostic test emerged as the most frequently employed, appearing in 49 articles. This suggests that the four-tier diagnostic test holds significant potential for identifying students' misconceptions in a more comprehensive manner. The four-tier diagnostic test developed as an extension of the three-tier format, adds a confidence level to students' reasoning, thereby offering a more complete and accurate representation of their conceptual understanding (Wati, 2024). This instrument enables more specific categorization of students' conceptual understanding, lack of understanding, misconceptions, and errors (Triastutik et al., 2021). Its strength lies in distinguishing students' confidence in both answers and reasoning, which significantly enhances diagnostic accuracy (Sarni et al., 2023). Additionally, the four-tier diagnostic test supports teachers in mapping misconceptions at the sub-topic level, helping them design more targeted instruction. Unlike traditional assessments, it considers not only students' answers but also their reasoning and confidence levels, providing a deeper insight into conceptual understanding (Zulfikar et al., 2017). The structure of the four-tier diagnostic test allows for clearer classification into categories such as conceptual understanding, misconceptions, and errors, offering valuable information for educators.

Furthermore, the application of the four-tier diagnostic test enabled teachers to effectively diagnose students' conceptual frameworks and determine which physics concepts required greater instructional focus (Yuliana & Suranti, 2024). In contrast, the six-tier diagnostic test appeared to be the least utilized, with only four studies indexed in Google Scholar. These studies focused on limited topics such as astronomy (Utari et al., 2021), linear motion (Sari & Mufit, 2023), waves (Utami & Khotimah, 2023), and projectile motion (Hidayat & Mufit, 2024). The six-tier diagnostic test remained rarely applied in physics education research due to its complexity and the high cognitive load it placed on respondents (Hidayat & Mufit, 2024). In addition to findings on the development of diagnostic tests from 2015 to 2025, the review also highlighted the physics topics that were assessed using diagnostic tests to identify students' misconceptions. Based on the reviewed articles, a wide range of physics topics in Indonesia have been investigated using diagnostic tools. These studies aimed to explore and classify students' understanding and misconceptions in specific physics content areas. The distribution of these topics is presented in Figure 3.

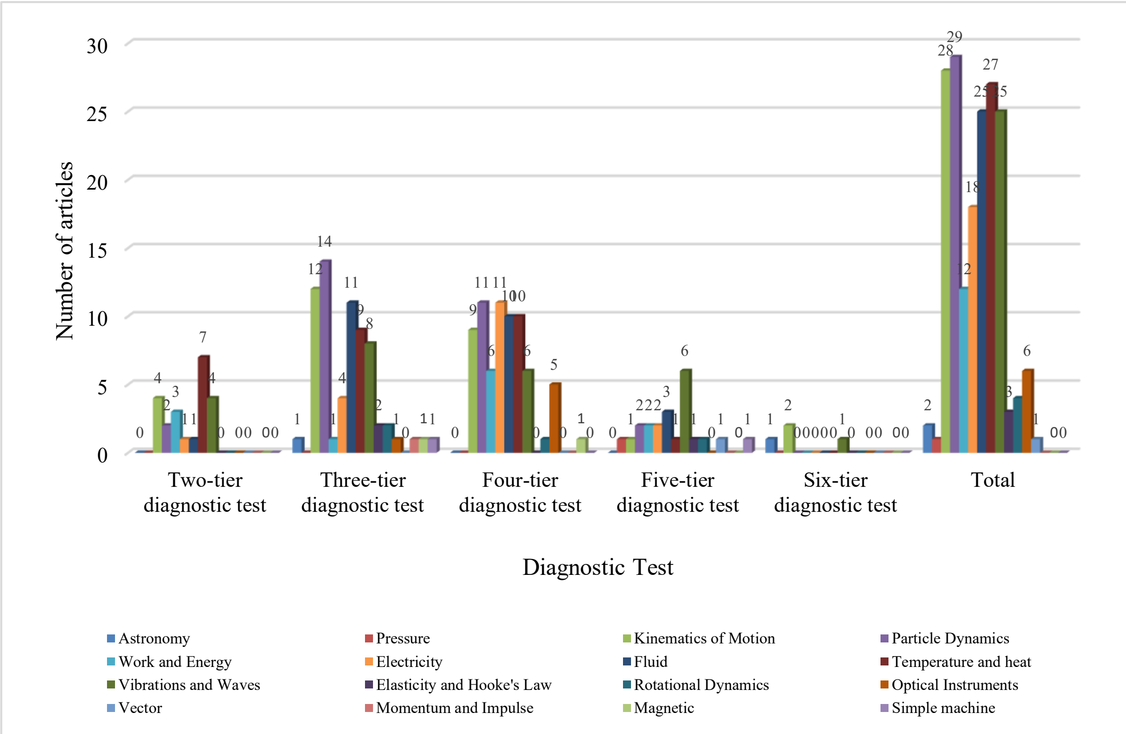

Figure 3. Comparison of physics material distribution with diagnostic tests

Figure 3 illustrates the physics topics most frequently examined using diagnostic tests. The most commonly investigated topics included particle dynamics, heat and temperature, and vibrations and waves, as these areas were found to involve high levels of student misconceptions. Misconceptions on the topic of Particle Dynamics accounted for 31.4% (Widayani, 2023). The highest rate of misconceptions occurred in the subtopic of frictional force and Newton's laws, with 54.86% (Busyairi et al., 2022), while the lowest was in the subtopic of spring force, at 40% (Maulini et al., 2017). In the topic of Heat and Temperature, misconceptions were observed in 65% of the students, particularly in subtopics such as temperature measurement, thermal expansion, and heat transfer (Apriyanti et al., 2024). The highest misconception rate reached 70% in the subtopics of thermal expansion and heat transfer, while the lowest was 60% in temperature measurement. These findings suggested that students' conceptual understanding of heat and temperature remained relatively low (Suhaila et al., 2024). Misconceptions in vibrations and waves exceeded 60% (Koriah & Jumini, 2024). The highest rate of misconception (64.2%) was identified in the indicator related to distinguishing between the characteristics of transverse and longitudinal waves, while the lowest rate (56.7%) was found in identifying waveforms of transverse and longitudinal waves (Haerunnisa et al., 2022).

Conversely, diagnostic tests were less frequently applied to topics like astronomy, pressure, and vectors. This was mainly due to the ongoing validation of diagnostic instruments for these areas. The validation of the six-tier diagnostic test for astronomy indicated that the items were acceptable across all aspects and could be used to detect misconceptions in astronomy concepts (Utari et al., 2021). Similarly, the five-tier diagnostic test developed for vectors was found to be both valid and reliable for identifying students' misconceptions (Qonita & Ermawati, 2020). The development of a five-tier diagnostic test for pressure was categorized as feasible and appropriate for identifying misconceptions in that area (Sandra et al., 2022). The publication years of studies addressing various physics topics were also analyzed, as shown in Figure 4.

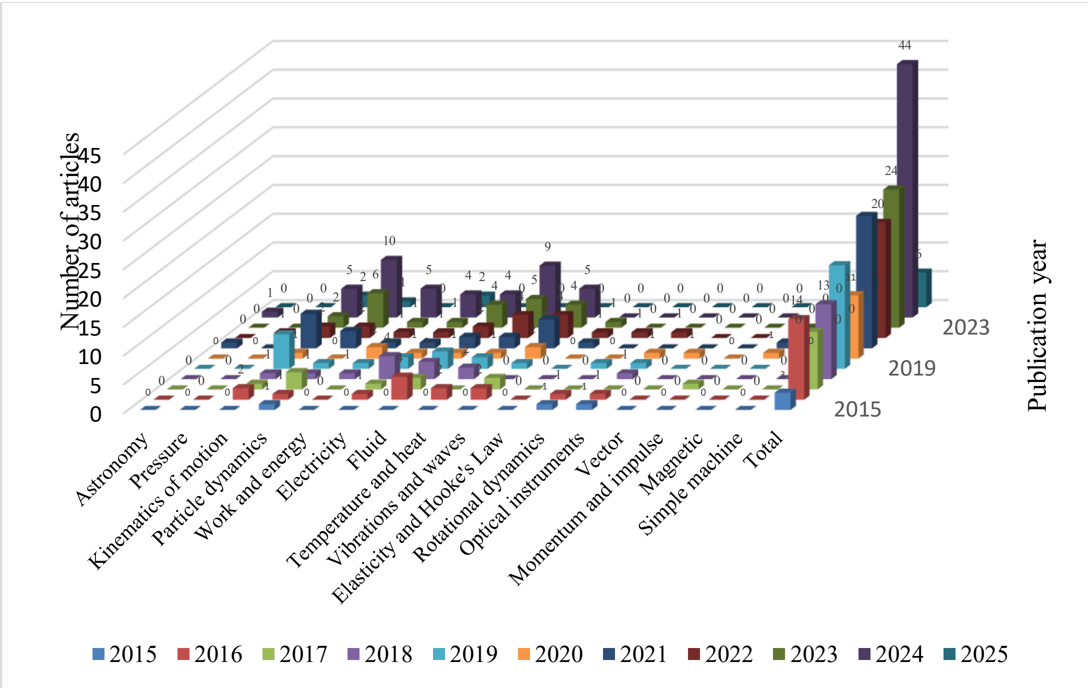

Figure 4. Use of physics material in the period 2015-2025

Illustrates the publication years of studies on physics topics using diagnostic tests. The year 2024 recorded the highest number of studies, with a total of 20 articles, most of which focused on the topic of particle dynamics. In contrast, the fewest studies were conducted in 2015, with only three articles identified. This study had several important implications and limitations. The findings provided a comprehensive overview of the use of diagnostic tests to identify misconceptions about various physics topics within the Indonesian context. These insights could guide educators in selecting appropriate diagnostic tools, especially the four-tier diagnostic test, which was shown to be the most widely used and effective in addressing students' misconceptions. In practical classroom settings, teachers could implement four-tier diagnostic test-based instruments using platforms such as Google Forms, Quizzes, or Edmodo, which allow for tiered question formatting and confidence rating features. Additionally, tools like Plickers or Socrative may be adapted to support multi-tier diagnostics, enabling real-time feedback and data analysis to inform targeted instruction.

Moreover, the study highlighted specific physics concepts such as particle dynamics, heat and temperature, and waves where misconceptions were prevalent, offering direction for future instructional interventions. The findings of this study are consistent with previous research, which revealed that students frequently conflate the concepts of heat and temperature, often assuming that the two are identical or directly proportional (Fenditasari et al., 2020; Gurcay & Gulbas, 2015; Nabilah et al., 2019). In line with these findings, misconceptions in the domain of Particle Dynamics remain prevalent among students. Numerous studies have reported that learners frequently misinterpret Newton's laws, particularly in understanding the relationship between force, mass, and acceleration. Misunderstandings related to inertia and the nature of motion are also common, with many students believing that a constant force is necessary to sustain motion an idea that contradicts Newton's first law (Istiyono et al., 2023). Furthermore, students often demonstrate inaccurate conceptions of velocity and acceleration, as well as difficulties in interpreting motion graphs, which further indicate gaps in their conceptual understanding of kinematics and dynamics (Admoko & Suliyanah, 2023; Mellu et al., 2022). These persistent misconceptions highlight the necessity for diagnostic tools that can precisely identify such conceptual errors to inform more effective instructional strategies

Misconceptions related to wave phenomena, including mechanical and electromagnetic waves, were also found to be significant. Students often possessed fragmented knowledge about wave propagation, hindering the development of deep conceptual understanding (Xie et al., 2021). Misunderstandings about the properties of mechanical waves, such as the belief that wave speed depends on amplitude and frequency, were commonly observed (Saparini et al., 2021). Furthermore, even advanced students struggled with concepts in wave optics, frequently confusing the phenomena of interference and diffraction (Mešić et al., 2019; Wahyuni et al., 2022). At a more detailed level, students found it challenging to comprehend the nature of electromagnetic waves, primarily due to their abstract characteristics and the intensive mathematical reasoning required (Gong et al., 2016). However, this research was limited to articles published within the Indonesian context and indexed on Google Scholar, potentially excluding relevant international studies and databases. Additionally, some diagnostic test formats, such as the Six-Tier Test, had limited empirical evidence, which constrained broader generalization. Future research should include a wider range of international databases and focus on under-researched physics topics to develop more valid and reliable diagnostic instruments.

This review significantly contributes to the development of physics education by synthesizing a decade's worth of research on diagnostic test evolution and identifying practical, evidence-based tools for detecting misconceptions. By highlighting the effectiveness of four-tier diagnostic test and mapping its usage across various physics topics, this study offers educators a strategic framework for selecting and implementing appropriate diagnostic tools. Furthermore, it informs curriculum developers about the pressing conceptual areas requiring attention and resource allocation. The findings have several implications for future research and practice. First, further empirical studies are needed to test and refine higher-tier diagnostic formats like six-tier diagnostic test in diverse educational settings. Second, the development of diagnostic instruments for lesser-studied topics such as Astronomy and Vectors should be prioritized to broaden the scope of misconception diagnostics. Lastly, teacher training programs should integrate the design and application of tiered diagnostic tests, ensuring that educators are well-equipped to utilize these tools effectively. These steps are essential for fostering conceptual understanding, improving instructional design, and advancing the overall quality of physics education.

IV. CONCLUSION AND SUGGESTION

The development of diagnostic test instruments aimed at identifying students' misconceptions in physics from 2015 to 2025 has shown considerable diversity. Various test formats have been employed, including two-tier, three-tier, four-tier, five-tier, and six-tier diagnostic tests. Among these, the four-tier diagnostic test emerged as the most frequently researched, appearing in 49 studies, while the six-tier diagnostic test was the least utilized. Commonly misconceived topics in physics included particle dynamics, heat and temperature, and vibrations and waves. Additionally, 2024 marked the peak in the frequency of publications related to diagnostic tests in physics education. These findings emphasize the increasing attention given to the use of diagnostic assessments to address students' conceptual difficulties and highlight the need for ongoing research to refine diagnostic tools, particularly for lesser-explored physics topics and test formats.

Despite the valuable insights provided by this study, several limitations should be considered. The research was restricted to articles published within the Indonesian context and indexed in Google Scholar, potentially excluding relevant international studies and limiting the generalizability of the findings. Furthermore, some diagnostic test formats, such as the six-tier diagnostic test, have limited empirical evidence and have only been applied to a few topics, making it difficult to comprehensively evaluate their efficacy. While multi-tiered tests have shown promising results in identifying misconceptions, their complexity and the high cognitive load they impose on students may hinder their broader implementation. Future research should address these gaps by expanding the scope to include international databases, exploring underrepresented physics topics, and validating the practicality of complex diagnostic tools in classroom settings. This study contributes to the field of physics education by providing a detailed map of the evolution and application of tiered diagnostic assessments in Indonesia, offering a foundation for informed instructional decision-making, and guiding future development of effective diagnostic instruments to improve students' conceptual understanding.

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