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The use of diagnostic assessment in high school physics learning: a systematic literature review from 2020-2024

Serli Ahzari[1], Nisa Cantika Fitri[1], Festiyed[2], Emiliannur[2]

[1]Magister of Physics Education, Universitas Negeri Padang, Indonesia

[2]Department of Physics, Universitas Negeri Padang, Indonesia

Email: serliahzari@student.unp.ac.id

Abstract
Diagnostic assessment is essential for identifying students' weaknesses and misconceptions in physics learning. It allows teachers to provide more targeted instruction and helps students understand better. This study aims to identify research related to diagnostic assessment in high school physics learning. The research method used is SLR (Systematic Literature Review), which uses data sources from Google Scholar accessed through the Publish or Perish application. Ten articles published between 2020 and 2024 were systematically reviewed according to predetermined criteria. This study identifies various diagnostic assessments in high school physics learning, types of instruments, and the effectiveness of the instruments used in previous studies. This study also discusses the benefits and challenges of using diagnostic assessment in high school physics learning. The results show that multi-tier diagnostic tests are most commonly used for identifying misconceptions, with four-tier and five-tier tests being particularly effective tools for improving high school physics learning. Diagnostic assessment can help teachers identify students' weaknesses and misconceptions, provide more targeted instruction, and help students achieve a deeper understanding.

Keywords: assessment, physics learning, high school, systematic literature review

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I. Introduction

Physics education at the high school level aims to develop student's conceptual understanding of natural phenomena and the underlying principles of physics. However, research shows that students often struggle to understand abstract and complex physics concepts and develop misconceptions that can hinder further learning [1]–[4]. Diagnostic assessment has been recognized as a valuable tool for identifying students' learning difficulties and misconceptions and informing effective instructional strategies [5], [6].

A diagnostic assessment is a formative assessment designed to reveal students' understanding and misunderstandings of key concepts in physics [7]–[10]. Unlike summative assessment, which focuses on evaluating student learning at the end of instruction, diagnostic assessment is conducted before or during the learning process to identify students' strengths and weaknesses [11]. Teachers can use the information obtained from diagnostic assessments to adjust instruction, provide targeted feedback, and design appropriate interventions to address students' misconceptions [12], [13]. Various diagnostic assessment instruments have been developed and employed in physics education, including graded multiple-choice tests [14], essay tests [8], and concept maps [15]. While the effectiveness of these diagnostic tools in identifying students'

misconceptions has been explored in various studies [8], [14], recent comprehensive reviews consolidating these findings are still lacking.

Previous systematic reviews on diagnostic assessments in science education and physics education have contributed significantly to the understanding of trends and developments in this area [9], [16], [17]. However, these reviews primarily focus on studies published over a decade ago, while significant advancements have been made in diagnostic assessments since then. For instance, recent studies have addressed the efficacy of multi-tiered diagnostic tests, such as the four-tier model, to detect misconceptions among high school students in physics [18]. Moreover, these studies provide more focused insights into how diagnostic tools inform teaching strategies and student learning [14], [16], which was not adequately explored in earlier reviews.

Therefore, an updated systematic review is needed to focus on research on diagnostic assessment in high school physics learning over the past five years (2020-2024) to identify recent progress, current trends, and future directions in this field. The objectives of this systematic literature review (SLR) are to (1) analyze trends and developments in research on diagnostic assessment in high school physics learning from 2020 to 2024 and (2) identify the types of diagnostic assessments used, key findings, and implications for future learning practices and research. This SLR will address the following research questions:

1. What are the publication trends of research on diagnostic assessment in high school physics learning from 2020 to 2024?
2. What types of diagnostic assessment instruments are most frequently used in research during this period?
3. What are the main findings regarding the effectiveness of diagnostic assessment in identifying students' misconceptions and improving their conceptual understanding?
4. How is diagnostic assessment used to inform instructional strategies and interventions in high school physics learning?
5. What are the challenges and opportunities for future research and practice of diagnostic assessment in high school physics learning?

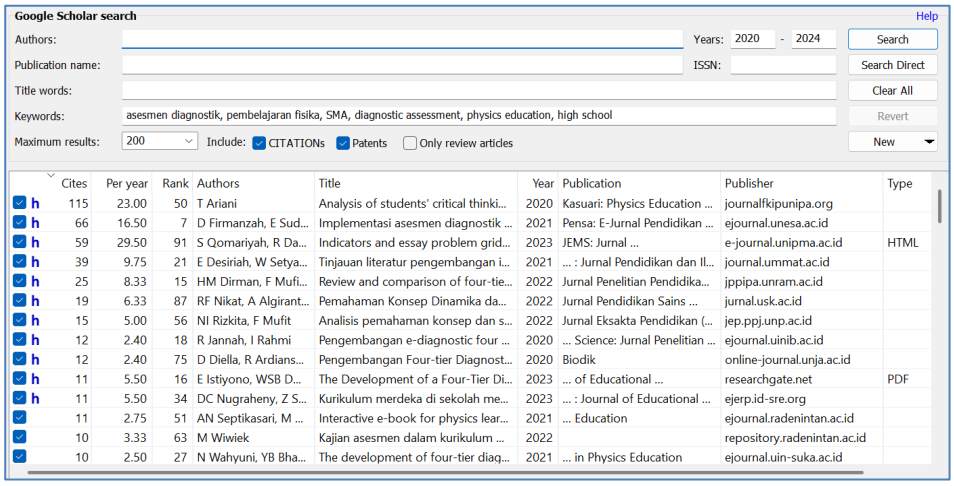
By answering these questions, this SLR will contribute to developing knowledge about diagnostic assessment in high school physics learning, provide evidence-based recommendations for educational practice, and highlight potential directions for future research. This review will benefit researchers, educators, and policymakers interested in improving students' physics learning through the effective use of diagnostic assessment.

II. Methods

This study was organized around the systematic literature review (SLR) method, which involved identifying, reviewing, evaluating, and interpreting all available research. The researchers conducted a systematic review of articles relevant to the research question, following predetermined steps at each stage of the process [8], [14], [19]–[22]. The inclusion criteria used in this study were research articles published in scientific journals or conference proceedings from 2020 to 2024, articles focusing on diagnostic assessment in physics learning at the high school level, and articles written in Indonesian or English. Exclusion criteria included articles that did not discuss diagnostic assessment in the context of high school physics learning, articles that did not include empirical data or analysis, and articles that were literature reviews or conceptual articles.

The researchers chose the theme "*diagnostic assessment in high school physics learning*" as the topic for the study. Data collection for the literature study was carried out by searching for articles on Google Scholar through the Publish or Perish application using the keywords "*assessment diagnostic,*" "*pembelajaran fisika,*" "*SMA,*" "*diagnostic assessment,*" "*physics education,*" and "*high school.*" The researchers limited the number to 200 articles from 2020 to 2024. The search results through Publish or Perish are displayed in Figure 1.

The study selection process consisted of two stages. First, the titles and abstracts of articles identified through the initial search were examined to determine their relevance based on the inclusion and exclusion criteria. In this stage, 175 articles were excluded because they were not directly related to diagnostic assessment in high school physics learning or were not published in scientific journals. Second, the full text of 25 potentially relevant articles was obtained and evaluated to ensure they met the inclusion criteria. After a detailed examination, 15 additional articles were excluded because they did not include empirical data or were conceptual. Subsequently, the researchers selected the remaining 10 articles to be reviewed, analyzed, and re-examined in detail related to the study theme.



Google Scholar search — Help

Authors: | Years: 2020 - 2024 | Search

Publication name: | ISSN: | Search Direct

Title words: | Clear All

Keywords: asesmen diagnostik, pembelajaran fisika, SMA, diagnostic assessment, physics education, high school | Revert

Maximum results: 200 | Include: CITATIONs, Patents, Only review articles | New

	Cites	Per year	Rank	Authors	Title	Year	Publication	Publisher	Type
h	115	23.00	50	T Ariani	Analysis of students' critical thinki...	2020	Kasuari: Physics Education ...	journalfkipunipa.org	
h	66	16.50	7	D Firmanzah, E Sud...	Implementasi asesmen diagnostik ...	2021	Pensa: E-Jurnal Pendidikan ...	ejournal.unesa.ac.id	
h	59	29.50	91	S Qomariyah, R Da...	Indicators and essay problem grid...	2023	JEMS: Jurnal ...	e-journal.unipma.ac.id	HTML
h	39	9.75	21	E Desiriah, W Setya...	Tinjauan literatur pengembangan i...	2021	... : Jurnal Pendidikan dan Il...	journal.ummat.ac.id	
h	25	8.33	15	HM Dirman, F Mufi...	Review and comparison of four-tie...	2022	Jurnal Penelitian Pendidika...	jppipa.unram.ac.id	
h	19	6.33	87	RF Nikat, A Algirant...	Pemahaman Konsep Dinamika da...	2022	Jurnal Pendidikan Sains ...	jurnal.usk.ac.id	
h	15	5.00	56	NI Rizkita, F Mufit	Analisis pemahaman konsep dan s...	2022	Jurnal Eksakta Pendidikan (...	jep.ppj.unp.ac.id	
h	12	2.40	18	R Jannah, I Rahmi	Pengembangan e-diagnostic four ...	2020	... Science: Jurnal Penelitian ...	ejournal.uinib.ac.id	
h	12	2.40	75	D Diella, R Ardians...	Pengembangan Four-tier Diagnost...	2020	Biodik	online-journal.unja.ac.id	
h	11	5.50	16	E Istiyono, WSB D...	The Development of a Four-Tier Di...	2023	... of Educational ...	researchgate.net	PDF
h	11	5.50	34	DC Nugraheny, Z S...	Kurikulum merdeka di sekolah me...	2023	... : Journal of Educational ...	ejerp.id-sre.org	
	11	2.75	51	AN Septikasari, M ...	Interactive e-book for physics lear...	2021	... Education	ejournal.radenintan.ac.id	
	10	3.33	63	M Wiwiek	Kajian asesmen dalam kurikulum ...	2022		repository.radenintan.ac.id	
	10	2.50	27	N Wahyuni, YB Bha...	The development of four-tier diag...	2021	... in Physics Education	ejournal.uin-suka.ac.id	

Figure 1. Search results for articles through PoP (Publish or Perish)

III. Results and discussion

Publication Trends in Diagnostic Assessment Research

The research data included in the literature review is an analysis and summary of articles related to diagnostic assessment in high school physics learning. Figure 2 presents the number and percentage of articles on diagnostic assessment published from 2020 to 2024.

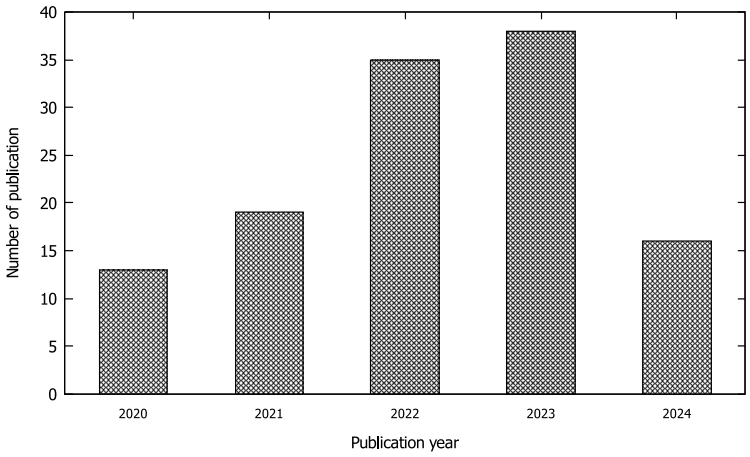


Figure 2. Percentage and number of articles published (2020-2024)

The data in Figure 2 shows a significant trend in research publications on diagnostic assessment in high school physics learning during 2020-2024. In 2020, 13 articles were published on this topic. This number increased substantially in 2021 with 19 articles and surged in 2022 with 35 articles, reaching its peak in 2023 with 38 articles. Despite a relative decline in 2024 with 16 articles, this number is still significant, especially considering that 2024 is still ongoing, meaning more publications on diagnostic assessment may appear later in the year. This increase in the number of publications reflects a growing interest from researchers and educators in exploring the potential of diagnostic assessment to improve physics learning at the high school level. Several factors that contribute to this trend are increasing recognition of the importance of identifying and addressing students' misconceptions in physics learning [8], [14], [20]–[22], technological advancements that enable the development of more sophisticated and efficient diagnostic assessment instruments, such as computer-based assessments [23], [24], increased international collaboration and knowledge exchange among physics researchers and educators [13], and greater emphasis on student-centered learning approaches and formative assessment in science education [12].

Although the overall trend shows an increase, it is essential to note that various factors, such as the availability of research funding, educational policy priorities, and global challenges like the COVID-19 pandemic, can influence the number of publications. The decline in the number of publications in 2024 may

reflect the ongoing impact of the disruptions caused by the pandemic on educational research [25]. Overall, this increasing publication trend highlights the growing knowledge base on diagnostic assessment in high school physics learning. These findings also indicate the potential for further research in developing and implementing practical diagnostic assessments to improve students' conceptual understanding and inform teaching practices.

Analysis of Diagnostic Assessment Research in High School Physics Learning

Table 1 presents an analysis of ten selected studies on diagnostic assessment in high school physics learning published between 2020 and 2024.

Table 1. Research results on diagnostic assessment in high school physics learning

No	Researchers & Year	Journal	Research Findings
1	Ekawati et al. (2024)	Journal of Educational Research and Evaluation	The results showed that the diagnostic assessment instrument developed to measure students' critical reasoning skills in physics was perfect. This instrument can assist teachers in designing learning that suits students' initial abilities in critical reasoning [26].
2	Prastyo et al. (2024)	Indonesian Journal of Science and Education	The results showed that many students needed help understanding the concepts of momentum and impulse and applying these concepts in calculations and everyday problem-solving. The four-tier diagnostic assessment instrument helped identify students' misconceptions, enabling better planning of learning in the Merdeka curriculum [27].
3	Istiyono et al. (2023)	European Journal of Educational Research	This study created a Four-Tier Diagnostic Test (FTDT) based on modern test theory to evaluate students' conceptual understanding of physics, which can help improve physics learning at various educational levels [10].
4	Fitri et al. (2023)	Pendidikan MIPA	The results showed that developing a Five-Tier Diagnostic Test could help teachers identify misconceptions about Elasticity and Hooke's Law. Hopefully, this innovation can enhance students' understanding of complex physics concepts and help address frequently occurring misconceptions [28].
5	Kurniawan et al. (2023)	Penelitian dan Pengembangan Pendidikan Fisika (JPPPF)	This study aimed to develop a web-based diagnostic test as a tool to identify students' misconceptions about the topic of work and energy. This study used the ADDIE development model to design the diagnostic test. Using web media to assess students' misconcepstions in physics education has great potential benefits [29].
6	Wahyono et al. (2023)	Jambura Physics Journal	The findings of this study suggest that the assessment can effectively gauge students' grasp of sound wave concepts and pinpoint the challenges they encounter in comprehension. This valuable information can empower educators to develop more effective instructional approaches for enhancing students' comprehension of sound waves [30].
7	Setiawan. (2023)	Jurnal Pendidikan Mandala	Based on expert validation, the research findings demonstrate that the assessment exhibits high validity, with an average questionnaire score of 78.8%. Moreover, the assessment displays normal data distribution and reliability, as evidenced by Cronbach's alpha coefficient of 0.693. Consequently, this assessment is deemed appropriate for evaluating critical thinking skills and the interplay of different critical thinking aspects in kinematics [31].
8	Fitriyah & Handayani (2023)	Unnes Physics Education Journal	This study utilized various diagnostic methods to assess high school students' misconceptions about Newton's laws, such as multiple-choice tests, open-question tests, multitier tests, and multi-diagnostic tests. The findings indicated that graded tests were the most commonly employed method for identifying misconceptions,

No	Researchers & Year	Journal	Research Findings
			followed by open-ended and multiple-choice tests. These results underscore the significance of choosing suitable diagnostic approaches to recognize student misconceptions in comprehending scientific principles like Newton's laws [32].
9	Asriadi et al. (2023)	Journal of Research and Educational Research Evaluation	This research presents evidence that the diagnostic assessment model of critical thinking skills in the domain of physics is not only reliable and valid but also has excellent item quality for achieving students' critical thinking competence. This research provides information to physics teachers in improving the quality of teaching physics lessons [33].
10	Suban et al. (2020)	Advances in Social Science, Education and Humanities Research	The research findings indicate that students' data literacy skills are in the moderate category and need improvement. The research suggests using diagnostic tests to pinpoint student weaknesses in data literacy. These results can serve as a reference for educators and researchers to create well-crafted test questions that accurately assess students' data literacy skills [34] .

Based on Table 1, the following is a discussion to answer the SLR questions asked:

a. Type of Diagnostic Assessment Instrument

The type of diagnostic assessment instrument most frequently used during the 2020-2024 period is a multi-tier test, such as the Four-Tier Diagnostic Test (FTDT) and Five-Tier Diagnostic Test. Some researchers use web-based diagnostic tests to identify student misconceptions. In addition, multiple-choice tests, open-ended question tests, and multi-diagnostic tests have also been used in some studies. Below are presented in Table 2 the types of diagnostic assessments that are often used.

Table 2. Types of diagnostic assessment instruments most frequently used

No	Researchers & Year	Type of Instrument	Information
1	Istiyono et al. (2023)	Four-Tier Diagnostic Test (FTDT)	Researchers developed FTDT based on modern test theory to evaluate students' understanding of the level of physics concepts [10].
2	Fitri et al. (2023)	Five-Tier Diagnostic Test	Researchers developed the Five-Tier Diagnostic Test to help teachers identify misconceptions about Elasticity and Hooke's Law material [28].
3	Kurniawan et al. (2023)	Four-tier web-based diagnostic test	Researchers developed a web-based diagnostic test to identify student misconceptions in work and energy material [29].
4	Fitriyah & Handayani (2023)	Multiple choice tests, open question tests, multi-tiered tests, and multi-diagnostic tests	Researchers use various diagnostic methods to analyze students' misconceptions about Newton's laws in high school [32].

b. Effectiveness of Diagnostic Assessment

The research results show that the diagnostic assessment instrument developed effectively identifies students' misconceptions and measures their conceptual understanding of various physics topics, such as momentum and impulse, elasticity and Hooke's law, work and energy, and sound waves. Diagnostic assessments help teachers design learning that suits students' initial abilities and overcome their difficulties in understanding physics concepts. The following explanation is presented in Table 3.

Based on Table 3, it is evident that diagnostic assessment is an effective tool for identifying student misconceptions and improving their conceptual understanding of physics learning. Furthermore, several studies show that the results of diagnostic assessments are used to inform learning strategies and interventions in high school physics learning in several ways. These include helping teachers design learning that is appropriate to students' initial abilities in critical reasoning [26], planning better learning in the Merdeka curriculum [27], designing learning to improve students understanding of complex physics concepts, such as

sound waves [30], becoming a reference for teachers to improve the quality of physics learning [33] and identifying student weaknesses related to data literacy to develop appropriate test questions [34].

These findings indicate that diagnostic assessments inform learning strategies and interventions in high school physics learning by helping teachers design learning that suits students' abilities and needs and improving the overall quality of physics learning. Some challenges in diagnostic assessment research and practice include developing valid and reliable instruments to measure students' conceptual understanding and identify misconceptions in various physics topics [30], [31]. In addition, efforts are needed to improve students' data literacy skills, which can be a focus in developing diagnostic assessments [34].

This study was limited to analyzing ten articles from 2020 to 2024, potentially missing earlier relevant research. Opportunities for future research include the use of technology, such as web-based diagnostic tests, to increase the efficiency and effectiveness of diagnostic assessments, further research on the relationship between diagnostic assessment results and effective learning strategies in overcoming student misconceptions, development of diagnostic assessments that can measure higher-order thinking skills, such as critical reasoning, and the integration of diagnostic assessments in the Merdeka curriculum to plan better learning.

Table 3. Main findings regarding the effectiveness of diagnostic assessment

No	Researchers & Year	Findings Regarding Diagnostic Assessment
1	Ekawati et al. (2024)	Found that the diagnostic assessment instruments developed to measure students' critical reasoning abilities in physics were very good and could help teachers in designing appropriate learning [26].
2	Prastyo et al. (2024)	Showed that a four-level diagnostic assessment instrument helps identify students' misconceptions about momentum and impulse so that better learning can be planned in the Merdeka curriculum [27].
3	Istiyono et al. (2023)	States that the Four-Tier Diagnostic Test (FTDT) can help improve physics learning at various levels of education [10].
4	Fitri et al. (2023)	Hopes that the Five-Tier Diagnostic Test innovation can improve students' understanding of complex physics concepts and help overcome common misconceptions [28].

IV. Conclusions

Based on the articles reviewed, this systematic literature review on diagnostic assessment in high school physics learning from 2020 to 2024 reveals several important findings. First, there has been a significant increase in publications on this topic, with the highest number occurring in 2023, indicating growing interest in this field. Second, multi-tier diagnostic tests, particularly four-tier and five-tier tests, are the most commonly used instruments for identifying misconceptions in high school physics learning. Web-based diagnostic tests are also emerging as efficient tools for assessment. The findings demonstrate that diagnostic assessment is an effective tool for improving high school physics learning by helping teachers identify students' weaknesses and misconceptions. This leads to more targeted instruction and deeper student understanding. The research also highlights how diagnostic assessments inform teaching strategies and interventions in the Merdeka curriculum, enhancing overall physics education quality.

However, challenges remain in developing valid and reliable diagnostic instruments for various physics topics and improving students' data literacy skills. Future research opportunities include leveraging technology for more efficient assessments, investigating the relationship between diagnostic results and effective learning strategies, developing tools to measure higher-order thinking skills, and integrating diagnostic assessments into curriculum planning. This study was limited to analyzing ten articles from 2020 to 2024, potentially missing earlier relevant research. Future studies should consider a broader timeframe and implement year-by-year searches to minimize selection bias. Despite these limitations, this review provides valuable insights for educators and researchers seeking to enhance physics learning through practical diagnostic assessment.

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