

Needs Analysis of Two-Tier Critical Thinking Assessment in High School Physics: Integrating Halpern and Tiruneh Frameworks

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Abstract

This study aims to analyze high school physics teachers' needs regarding the development of a two-tier assessment instrument to measure students' critical thinking skills. A descriptive quantitative approach was employed using a questionnaire distributed to 24 physics teachers across various regions. The instrument explored teachers' instructional practices, perceptions, knowledge, and experiences related to critical thinking assessment. The results indicate that teachers have begun to implement learning activities that support critical thinking and show a strong awareness of its importance. However, many teachers are not familiar with established critical thinking frameworks, and assessment practices remain focused on final answers rather than reasoning processes. These findings reveal a gap between teachers' awareness and the availability of appropriate assessment tools. Therefore, the development of a structured two-tier assessment instrument is needed to support more effective evaluation of students' critical thinking skills in physics learning.

Kata kunci: critical thinking, two-tier assessment, physics education, needs analysis, teachers' perception

INTRODUCTION

The rapid advancement of science and technology in the 21st century requires individuals who are not only knowledgeable but also capable of thinking critically, analytically, and systematically. Critical thinking has become one of the essential competencies that students must develop in order to address complex problems, make informed decisions, and adapt to dynamic societal changes. In science education, particularly physics, critical thinking is indispensable because understanding physical phenomena requires not only conceptual mastery but also the ability to analyze, evaluate, and interpret information logically (Sermeus et al., 2021; Yulvinamaesari et al., 2025).

Physics learning inherently involves abstract concepts and complex problem-solving processes. Students are expected to interpret data, connect theoretical principles with real-world phenomena, and construct logical arguments to explain observed events. Accordingly, the development of critical thinking skills in physics cannot be separated from both instructional practices and assessment strategies. However, in many classroom contexts, assessment practices remain focused on procedural knowledge and final answers rather than students' reasoning processes. Consequently, students' critical thinking skills are often insufficiently measured and inadequately developed (Sartono et al., 2025; Sugiarti et al., 2017).

To address this issue, various theoretical frameworks have been proposed to conceptualize critical thinking skills. The framework developed by Halpern highlights essential components such as verbal reasoning, argument analysis, hypothesis testing, decision-making, and problem-solving (Halpern, 2014; Tiruneh et al., 2017). In parallel, contemporary frameworks in science education emphasize the integration of cognitive processes with domain-specific contexts, as reflected in the work of Tiruneh et al. These frameworks provide a robust theoretical basis for designing assessment instruments capable of capturing higher-order thinking skills in a more comprehensive and meaningful way (Bhakti et al., 2023; SAPUTRO et al., 2020).

Despite the availability of such theoretical frameworks, previous studies indicate that many teachers still have limited understanding and experience in developing assessment instruments specifically designed to measure critical thinking skills. Similar findings were also reported in studies on

teachers' perceptions of higher-order thinking assessments, where many teachers expressed difficulties in developing structured thinking assessment instruments and showed interest in using framework-based assessments in physics learning (Susilowati et al., 2025). In practice, teachers often rely on conventional test formats that are not aligned with critical thinking indicators, resulting in a gap between theoretical expectations and classroom implementation. One promising alternative is the two-tier test format, which combines multiple-choice questions with reasoning-based responses. This format enables a more in-depth assessment of students' conceptual understanding as well as their reasoning processes (Cil, 2015; Lin, 2016; Yang et al., 2016).

However, studies that explicitly integrate critical thinking frameworks such as Halpern and Tiruneh within a two-tier assessment format, particularly in the context of physics education, remain limited. Moreover, there is still a lack of empirical studies that examine teachers' needs as a foundational step for developing such assessment instruments. Therefore, conducting a needs analysis is essential to identify gaps between current practices and ideal assessment conditions, as well as to provide a data-driven basis for instrument development (Jatmiko et al., 2025; Kassiavera et al., 2024).

This study aims to analyze the needs of high school physics teachers regarding the development of a two-tier critical thinking assessment instrument based on the Halpern and Tiruneh frameworks. The novelty of this study lies in the integration of these two theoretical frameworks into a structured two-tier assessment approach, grounded in empirical data on teachers' needs. The findings are expected to contribute to the development of more valid and practical assessment instruments that support the enhancement of students' critical thinking skills in physics learning.

METHOD

This study employed a descriptive research design with a quantitative approach to examine high school physics teachers' needs regarding the development of a two-tier assessment instrument for measuring students' critical thinking skills. This approach allows for the systematic identification of patterns in teachers' perceptions, experiences, and knowledge through structured data collection (Suprpto et al., 2024; Yulvinamaesari et al., 2025).

The research was conducted through several sequential stages, beginning with a literature review to identify key issues related to critical thinking skills, assessment practices in physics education, and relevant theoretical frameworks such as Halpern and Tiruneh. The findings from this stage were used to inform the development of the research instrument, followed by instrument development, data collection through online distribution, data processing, and data interpretation. To provide a clearer overview of the research procedure, the sequence of these stages is illustrated in Figure 1.

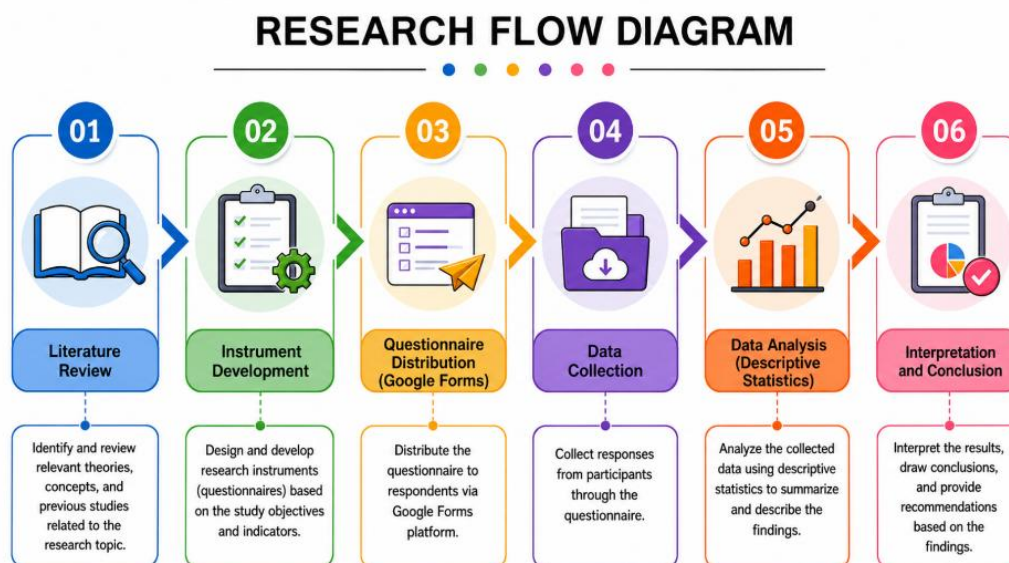


Figure 1. Research Procedure of the Study

Figure 1 shows that the research process was carried out in a systematic and sequential manner, where each stage is logically connected and contributes to achieving the research objectives, particularly in identifying teachers' needs related to critical thinking assessment.

The instrument used in this study was a needs analysis questionnaire developed by the researcher to explore teachers' practices, perceptions, knowledge, and experiences related to critical thinking assessment. The questionnaire also aimed to identify teachers' familiarity with theoretical frameworks such as Halpern's critical thinking indicators and the Tiruneh framework, which are commonly discussed in science education research.

Prior to distribution, the questionnaire was reviewed by two expert lecturers and one physics teacher to ensure the clarity, relevance, and appropriateness of the instrument items in accordance with the research objectives. This review process was conducted to strengthen the content appropriateness of the questionnaire before it was distributed to physics teachers.

The questionnaire was distributed using an online platform (Google Forms), allowing efficient data collection across different regions (Udyaningsih and Budiawanti, 2024). The distribution process was conducted from February 12, 2026, to March 9, 2026, using a convenience sampling technique based on the accessibility and voluntary participation of high school physics teachers. The instrument was designed to capture structured responses through Likert-scale items and multiple-choice questions, as well as limited open-ended responses to provide deeper insights into teachers' perspectives.

To provide a clearer overview of the questionnaire design, the structure of the instrument is presented in Table 1.

Table 1. Structure of the Questionnaire

Section	Statement or Question	Answer			
		SA	A	DA	SDA
Practice of Critical Thinking	1. I frequently ask students to explain the logical reasoning behind their answers during physics learning.				
	2. I provide opportunities for students to evaluate their classmates' arguments rationally.				
	3. I use contextual problems to foster students' critical thinking skills.				
	4. I encourage students to analyze experimental results that do not match their predictions.				
	5. I ask students to consider multiple alternative solutions to a physics problem.				
	6. I assess students' reasoning processes, not only their final answers.				
	7. I have discussed with fellow teachers about instructional strategies that can promote students' critical thinking skills.				
	8. My school supports the development of assessments that evaluate students' thinking processes.				
	9. I am interested in using a two-tier test format to measure students' critical thinking skills more comprehensively.				
With: SA = Strongly Agree A = Agree DA = Disagree SDA = Strongly Disagree					
Perception of Critical Thinking Assessment	Question	4	3	2	1
	1. How important are critical thinking skills for high school students in physics learning?				
	2. How important is it for teachers to understand students' critical thinking profiles?				
	3. How important is it to have specific instruments for measuring students' critical thinking skills?				
With: 4 = Very Important; 3 = Important; 2 = Not Important; 1 = Very Not Important					
Knowledge and Experience	Question		Y		N
	1. Have you ever heard of critical thinking skill indicators proposed by Halpern (2014)?				
	2. Are you aware that Halpern's critical thinking indicators include verbal reasoning, argument analysis, hypothesis testing, likelihood evaluation, decision making, and problem-solving as well as solution generation?				

3. Have you ever heard of the critical thinking framework in science education developed by Tiruneh et al. (2016)?
4. Have you ever developed or used an instrument to measure students' critical thinking skills?
5. Have you ever heard of or used the two-tier test format, which combines multiple-choice questions with reasoning-based responses to measure students' understanding and reasoning?

Suitable Physics Topics	Question
<p>Instructions: Please select the physics topics that you consider most appropriate for assessing students' critical thinking skills. (You may select more than one.)</p> <p><input type="checkbox"/> Newton's Laws and Motion <input type="checkbox"/> Work and Energy <input type="checkbox"/> Momentum and Impulse <input type="checkbox"/> Rotational Dynamics <input type="checkbox"/> Static Fluids <input type="checkbox"/> Dynamic Fluids <input type="checkbox"/> Waves and Sound <input type="checkbox"/> Dynamic Electricity <input type="checkbox"/> Magnetic Fields and Induction <input type="checkbox"/> Heat and Thermodynamics <input type="checkbox"/> Optics (Mirrors and Lenses)</p>	
Open-Ended Responses	Question
<ol style="list-style-type: none"> 1. In your opinion, why is it important to develop critical thinking skills in physics learning? 2. If you have ever assessed students' critical thinking skills, what types of questions or instruments did you use? Additionally, which critical thinking indicators did you refer to, and which theory or model were those indicators based on? 	

The respondents of this study were 24 high school physics teachers from various regions in Indonesia who participated voluntarily. The demographic characteristics of the respondents are presented in Table 2, while their geographical distribution is illustrated in Figure 2.

Table 2. Demographic Characteristics of Respondents

Characteristic	Category	n	(%)
Gender	Male	7	29.2
	Female	17	70.8
Age (years)	20–25	13	54.2
	26–30	4	16.7
	31–35	1	4.2
	36–40	3	12.5
	41–45	3	12.5
Educational Background	Bachelor of Physics Education	16	66.7
	Bachelor of Physics	3	12.5
	Master of Physics Education	2	8.3
	Master of Physics	2	8.3
	Professional Teacher Education Program	1	4.2
Teaching Experience	< 5 years	15	62.5
	5–10 years	3	12.5
	11–15 years	4	16.7
	16–20 years	2	8.3
Province	West Java	17	70.8
	Central Java	1	4.2
	D.I. Yogyakarta	1	4.2
	Jambi	1	4.2
	East Java	1	4.2
	Central Kalimantan	1	4.2
	Banten	1	4.2
	East Nusa Tenggara	1	4.2
Total		24	100

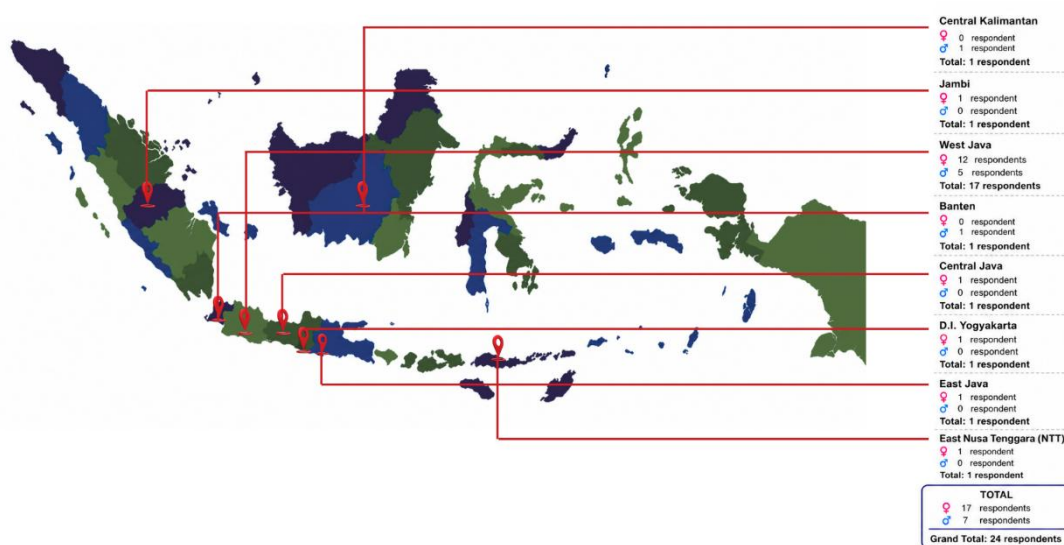


Figure 2. Geographical Distribution of Respondents

As shown in Table 2, the majority of respondents were female and predominantly early-career teachers. This indicates that the data reflect perspectives from teachers who are relatively new to professional teaching practice.

The data were analyzed using descriptive statistical techniques. Quantitative data were analyzed in the form of frequencies and percentages to identify general trends, while responses from open-ended questions were used as supporting qualitative data to enrich the interpretation of the results. This approach allows for a more comprehensive understanding of teachers' needs regarding critical thinking assessment (Essalih et al., 2025).

RESULT AND DISCUSSION

Result

The implementation of critical thinking practices in physics learning was examined through nine statements representing classroom activities that potentially support the development of students' critical thinking skills. These activities include encouraging students to explain logical reasoning, analyzing experimental results, considering alternative solutions, evaluating reasoning processes, and engaging in discussion. The distribution of teachers' responses is presented in Table 3.

Table 3. Practice of Critical Thinking Skills in Physics Learning (N = 24)

Statement	SA (n)	SA (%)	A (n)	A (%)	DA (n)	DA (%)	SDA (n)	SDA (%)
Asking students to explain logical reasoning	5	20.8	14	58.3	3	12.5	2	8.3
Students evaluate peers' arguments	8	33.3	7	29.2	4	16.7	5	20.8
Using contextual problems	8	33.3	11	45.8	3	12.5	2	8.3
Analyzing experimental results	6	25.0	10	41.7	5	20.8	3	12.5
Considering alternative solutions	6	25.0	10	41.7	6	25.0	2	8.3
Assessing reasoning processes	8	33.3	8	33.3	4	16.7	4	16.7
Discussion with fellow teachers	5	20.8	12	50.0	6	25.0	1	4.2
School support for thinking-based assessment	7	29.2	9	37.5	6	25.0	2	8.3
Interest in using Two-Tier Test	14	58.3	6	25.0	1	4.2	3	12.5

With: SA = Strongly Agree A = Agree DA = Disagree SDA = Strongly Disagree

The findings show that most teachers have implemented learning practices that support the development of students' critical thinking skills. This is indicated by the dominance of "agree" and "strongly agree" responses across most statements. A substantial proportion of respondents reported that they frequently ask students to explain the logical reasoning behind their answers, with 79.1% indicating agreement. A similar trend is observed in the use of contextual problems, where 79.1% of teachers reported integrating real-life situations into physics learning to stimulate analytical thinking. Activities such as analyzing experimental results, considering alternative solutions, and evaluating reasoning processes were also implemented by most teachers, each reaching 66.7%, suggesting that elements of higher-order thinking have begun to be incorporated into classroom instruction.

However, not all aspects of critical thinking practices have been optimally implemented. Opportunities for students to evaluate their peers' arguments remain limited, as indicated by 37.5% of respondents who expressed disagreement. This suggests that argumentation-based learning activities are still not consistently applied. In addition, although most teachers expressed interest in using the two-tier test format, a small proportion of respondents showed less interest, indicating that the adoption of more advanced assessment methods has not yet been fully optimized.

Teachers' perceptions regarding the importance of critical thinking assessment were further explored, and the results are presented in Table 4.

Table 4. Teachers' Perceptions of Critical Thinking Assessment (N = 24)

Item	VNI (1)	NI (2)	I (3)	VI (4)	VI (%)
Importance of critical thinking skills	1	0	2	21	87.5
Importance of knowing students' critical thinking profile	0	2	3	19	79.2
Importance of having specific assessment instruments	0	1	2	21	87.5

With: 4 = Very Important; 3 = Important; 2 = Not Important; 1 = Very Not Important

The results indicate that teachers have a highly positive perception of critical thinking in physics learning. A large majority of respondents (87.5%) stated that critical thinking skills are very important, while 79.2% emphasized the importance of identifying students' critical thinking profiles. Similarly, 87.5% of teachers agreed that specific instruments are needed to assess these skills, indicating a strong awareness of the importance of appropriate assessment tools.

Teachers' knowledge and experience related to critical thinking frameworks were also examined, and the results are presented in Table 5.

Table 5. Teachers' Knowledge and Experience (N = 24)

Item	Yes (n)	(%)	No (n)	(%)
Familiarity with Halpern's indicators	9	37.5	15	62.5
Familiarity with Tiruneh framework	8	33.3	16	66.7
Experience using critical thinking assessment tools	12	50.0	12	50.0

The findings reveal that many teachers are still not familiar with established theoretical frameworks of critical thinking. A total of 62.5% of respondents reported that they were not familiar with Halpern's critical thinking indicators, while 66.7% indicated that they were not familiar with the Tiruneh framework. Despite this limited theoretical understanding, half of the respondents reported having experience in using or developing instruments to assess critical thinking. This indicates that assessment practices may already exist, but are not necessarily grounded in established theoretical frameworks.

The suitability of physics topics for assessing critical thinking skills is presented in Figure 5.

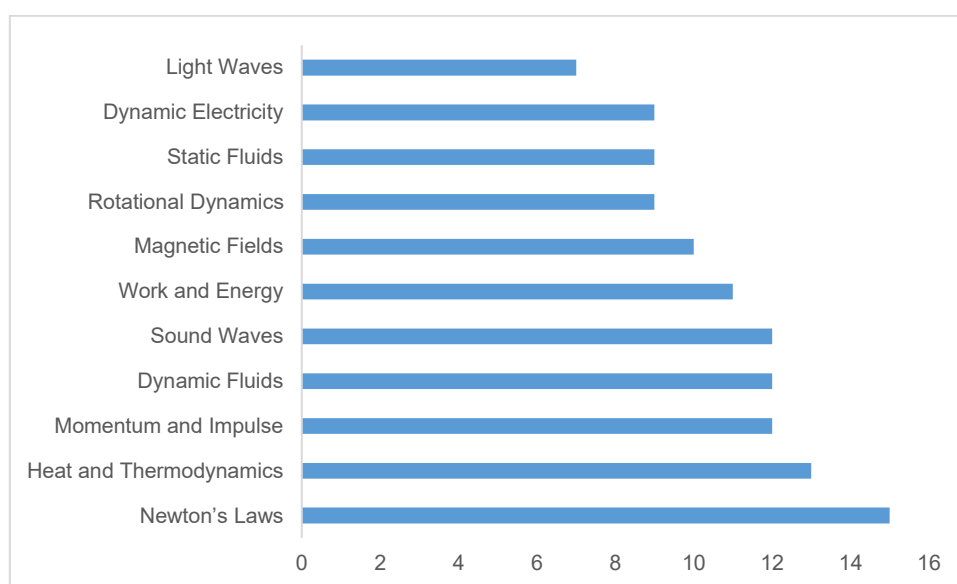


Figure 3. Suitable Physics Topics for Critical Thinking Assessment

The distribution shows that Newton’s Laws were the most frequently selected topic, followed by thermodynamics. Other topics such as momentum, fluid dynamics, and sound waves were also selected by a considerable proportion of respondents. This indicates that teachers tend to associate critical thinking assessment with topics that involve conceptual reasoning and problem-solving. At the same time, the spread of responses across almost all topics suggests that teachers perceive critical thinking as a skill that can be developed across various areas of physics rather than being limited to specific content domains.

To provide deeper insight, qualitative responses from teachers were analyzed and are presented in Tables 6 and 7.

Table 6. Teachers’ Responses on the Importance of Critical Thinking

Code	Province	Gender	Teaching Experience	Highest Degree	Response
R01	West Java	Female	< 5 years	BPE	“Critical thinking skills need to be developed in physics learning because they help students analyze concepts, solve problems, interpret data, develop scientific thinking, and improve transfer skills.”
R02	Central Java	Female	< 5 years	BP	“Physics requires students not only to memorize formulas but also to analyze phenomena, solve problems, and draw conclusions based on concepts and data.”
R05	East Java	Female	5–10 years	BPE	“Critical thinking helps students understand concepts deeply, solve problems logically, and apply physics in daily life.”
R06	Central Kalimantan	Male	< 5 years	BPE	“Critical thinking is important so that individuals can distinguish between facts and opinions and not accept information without analysis.”
R08	West Java	Female	< 5 years	BPE	“Physics does not only require memorizing formulas but also understanding concepts, analyzing natural phenomena, and solving problems logically.”
R09	West Java	Female	< 5 years	BPE	“Physics is not just about memorizing

Code	Province	Gender	Teaching Experience	Highest Degree	Response
					formulas but understanding concepts, analyzing relationships between variables, and reasoning systematically.”

***Notes:** BP= Bachelor (Physics); BPE= Bachelor (Physics Education)

The responses indicate that teachers view critical thinking as an essential component of physics learning. Respondents emphasized that physics requires not only memorization of formulas but also conceptual understanding, logical reasoning, and the ability to analyze phenomena and draw conclusions based on evidence. Critical thinking is also considered important for helping students connect concepts with real-life situations and develop scientific reasoning skills.

Table 7. Types of Assessment Instruments Used by Teachers

Code	Province	Gender	Teaching Experience	Highest Degree	Instrument Used
R02	Central Java	Female	< 5 years	BP	“Problem-based essay questions and inquiry worksheets with scoring rubrics.”
R05	East Java	Female	5–10 years	BPE	“Contextual problem-based essays and discussion observation sheets.”
R06	Central Kalimantan	Male	< 5 years	BPE	“Case-based essay questions requiring reasoning and conclusion.”
R09	West Java	Female	< 5 years	BPE	“Contextual problem-based essays and experimental worksheets with analytic rubrics.”
R12	West Java	Male	< 5 years	BPE	“Multiple-choice questions accompanied by factual data and graphs.”

***Notes:** BP= Bachelor (Physics); BPE= Bachelor (Physics Education)

The responses further show that teachers have used various forms of assessment, such as essay-based questions, inquiry-based worksheets, and experimental tasks, to evaluate students' thinking processes. These approaches are considered more effective in capturing reasoning processes compared to conventional multiple-choice tests. However, several respondents indicated that assessment practices are still not systematically designed to measure critical thinking, and in many cases, evaluation remains focused on final answers rather than reasoning processes.

Overall, the results indicate that teachers have begun to integrate critical thinking-oriented activities into physics learning and demonstrate a strong awareness of the importance of assessing these skills. Nevertheless, there remains a gap between teachers' awareness and the systematic implementation of theoretically grounded assessment instruments.

Discussion

The findings of this study reveal that physics teachers have begun to integrate activities that support the development of students' critical thinking skills into classroom practice. This is reflected in the high proportion of teachers who reported encouraging students to explain logical reasoning, analyze experimental results, and engage with contextual problems. Such practices are consistent with student-centered instructional approaches, such as inquiry-based learning and project-based learning, which have been widely reported to enhance students' critical thinking and problem-solving skills in physics education (Jatmiko et al., 2025; Salazar et al., 2023). This indicates a shift from purely procedural instruction toward learning environments that promote higher-order thinking processes.

However, the findings also indicate that certain aspects of critical thinking remain underdeveloped, particularly those related to argumentation and peer evaluation. This condition reflects a gap between theoretical frameworks of critical thinking which emphasize reflective reasoning and evaluative judgment and their practical implementation in classroom settings. Previous studies have similarly reported that while teachers tend to emphasize individual problem-solving, opportunities for collaborative reasoning and argumentation are often limited (Nabilah and Suyanto, 2025). This gap suggests that instructional practices have not yet fully supported the development of dialogic learning environments necessary for deeper critical thinking.

The strong positive perception of teachers toward the importance of critical thinking assessment further reinforces the relevance of this study. Most teachers recognized the importance of assessing critical thinking and expressed the need for specific instruments. This finding aligns with contemporary perspectives in science education, which emphasize that assessment should be closely aligned with cognitive processes and domain-specific contexts to accurately capture students' higher-order thinking (Jatmiko et al., 2025). Such awareness indicates that teachers are ready to adopt more structured and theoretically grounded assessment approaches.

Despite this positive perception, the results reveal a significant gap in teachers' knowledge of established critical thinking frameworks. Many teachers were unfamiliar with formal frameworks, suggesting that current assessment practices are often based on intuition rather than validated theoretical models. This condition may lead to inconsistencies in measuring critical thinking skills and weaken construct validity. Similar concerns have been highlighted in previous studies, which emphasize that the lack of theoretical grounding in assessment design can limit the effectiveness of measuring higher-order thinking skills (Nabilah and Suyanto, 2025).

Furthermore, although some teachers reported experience in assessing critical thinking through essays, inquiry tasks, and experimental activities, these approaches are not systematically designed. While such methods are capable of capturing students' reasoning processes, they may not fully represent the multidimensional nature of critical thinking without a structured framework. This reinforces the need for assessment formats that explicitly integrate conceptual understanding and reasoning processes in a measurable and consistent way.

In this context, the two-tier diagnostic test format emerges as a promising solution. Two-tier tests, which combine answer selection with reasoning justification, have been shown to improve the assessment of students' conceptual understanding and critical thinking by providing deeper insights into their thought processes (Cil, 2015; Kassiavera et al., 2024). This approach aligns with the need to move beyond answer-oriented assessment toward process-oriented evaluation, particularly in physics learning where conceptual reasoning is essential.

The distribution of responses regarding suitable physics topics further supports the idea that critical thinking is not limited to specific content areas. Nearly all physics topics were considered relevant for assessing critical thinking, indicating that it should be viewed as a cross-domain competency. This perspective is consistent with previous research, which emphasizes that critical thinking can be developed across various physics contexts as long as learning activities involve analysis, reasoning, and problem-solving.

Finally, the qualitative findings reinforce the overall pattern by showing that teachers perceive critical thinking as an essential component of physics learning. Teachers emphasized that physics requires not only memorization but also conceptual understanding and logical reasoning. However, they also acknowledged that current assessment practices are still limited and not fully aligned with these expectations. This highlights a clear gap between instructional intentions and assessment practices.

Overall, the findings indicate a mismatch between teachers' awareness of the importance of critical thinking and the availability of appropriate assessment tools. While instructional practices have begun to incorporate elements of critical thinking, assessment practices remain less developed and not yet systematically aligned with theoretical frameworks. Therefore, the development of a two-tier critical thinking assessment instrument that integrates established frameworks is essential to support more valid, reliable, and comprehensive measurement of students' critical thinking skills in physics education. However, several limitations should be considered when interpreting these findings. First, the number of respondents involved in this study was relatively small, consisting of only 24 high school physics teachers, which may limit the broader generalizability of the findings. In addition, most respondents were from West Java, resulting in unequal regional representation across Indonesia. Consequently, the findings may primarily reflect the perspectives and educational contexts of teachers from certain regions rather than representing physics teachers nationwide. Furthermore, the data were based on teachers'

self-reported perceptions and experiences, which may differ from actual classroom implementation. Nevertheless, this study provides important preliminary insights into teachers' needs regarding critical thinking assessment and offers a valuable foundation for future large-scale studies and the development of more comprehensive assessment instruments.

CONCLUSION

This study concludes that high school physics teachers have begun to integrate critical thinking elements into their instructional practices, particularly through activities that promote reasoning, problem-solving, and contextual understanding. Teachers also demonstrate a strong awareness of the importance of critical thinking and recognize the need for appropriate assessment tools. However, the findings reveal that the implementation of critical thinking assessment remains limited, as many teachers are not familiar with established theoretical frameworks and tend to focus on final answers rather than students' reasoning processes. This indicates a gap between teachers' awareness of critical thinking and the availability of structured, theory-based assessment instruments.

Based on these findings, it is recommended that teachers be provided with training and guidance on the development and implementation of critical thinking assessments, particularly those based on structured frameworks, in order to improve the quality of evaluation in physics learning. For researchers, further studies are needed to design and validate two-tier assessment instruments that integrate relevant theoretical frameworks to ensure both validity and practicality. In addition, educational institutions and policymakers are encouraged to support the integration of critical thinking assessment into classroom practice by providing resources, training programs, and assessment guidelines that align with current educational demands.

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