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Analysis of Students' Critical Thinking Abilities in Physics Learning: A Case Study at SMAN 5 Sidrap

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Abstract – *Critical thinking is one of the essential skills required of students in the 21st century. This research aims to provide an overview of students' critical thinking skills at in high school while studying the concept of Newton's Laws. Critical thinking skills refer to the cognitive processes employed by students to analyze and evaluate information effectively, enabling sound decision-making. The research method used is a descriptive-quantitative approach, involving a population of 130 students and a purposive sample of 60 students. Data were collected using a critical thinking test comprising 31 multiple-choice questions, addressing four indicators: interpretation, analysis, evaluation, and inference. The result of the study show that students' performance on the interpretation indicator predominantly fell into the low category, with 53.33%. Critical thinking skills for the analytical indicator were similarly low, at 38.33%. Critical thinking skills for evaluation were also categorized as low, at 43.33%. Meanwhile, critical thinking skills for inference were slightly better, being in the medium category at 46.67%. In general, students' critical thinking abilities at SMAN 5 Sidrap were primarily low, with 60% of students falling into this category. One of the factors causing students' poor critical thinking skills is the infrequent exposure to exercises designed to measure these skills. Therefore, implementing learning models that actively enhance critical thinking skills is essential.*

Keywords: *critical thinking skills; Newton's law; physics learning*

I. INTRODUCTION

One of the essential competencies in the 21st century is critical thinking (Azinah et al., 2022; Falloon, 2024; Li et al., 2024; Riaz & Din, 2023; Normore et al., 2024; Sujanem & Suwindra, 2023; Wibowo et al., 2024; Yusal et al., 2021). Critical thinking skills encompass the ability to access, analyze, and synthesize information, all of which can be cultivated and mastered (Dhewi & Ningrum, 2021; Siregar, 2024). These skills are closely linked to communication, information processing, and the ability to examine, analyze, interpret, and evaluate information (Danil et al., 2023; Pertiwi et al., 2021). It is a process involving the deployment of knowledge and skills to solve problems, analyze assumptions, and make accurate, data-informed decisions (Wicaksanti, 2023).

Students need to acquire and develop critical thinking skills as they are vital for tackling challenges in contemporary and future contexts (Arisoy & Aybek, 2021; Awaliyah, 2019; Shaw et al., 2020). Critical thinking fosters rational and logical reasoning, enables systematic problem-solving, and enhances analytical capabilities (Sarwanto et al., 2021; Miterianifa et al., 2020). It involves using knowledge and skills to address issues, evaluate assumptions, and make sound decisions based on systematic investigation (Wicaksanti, 2023).

Based on the 2023 Program for International Student Assessment (PISA), Indonesia ranked 68th, with scores of 379 in mathematics, 398 in science, and 371 in reading. A significant global decline in student performance across these disciplines has been observed over the last four years (2018–2022), marking an unprecedented trend. PISA assesses not only students' academic understanding but also their critical thinking, information interpretation, and problem-solving abilities in real-world contexts (Yusmar & Fadilah, 2023).

Based on observations at senior high school called SMAN 5 Sidrap, students struggled to interpret physics questions provided directly by educators. Data showed that out of 31 students, 21 required remediation for failing to meet the minimum score of 80. These findings highlight deficiencies in critical thinking indicators, particularly interpretation, analysis, and explanation, among high school physics students. Hence, critical thinking abilities in physics among students at SMAN 5 Sidrap require improvement.

According to Lestari (2022), who studied students' critical thinking abilities, concluded that their performance across six indicators was in the moderate category. The explanation indicator scored the lowest, categorized as not manifested, while the self-regulation indicator scored the highest, categorized as strong. Critical thinking on reproductive system material ranged from moderate in SMA A (78.81%) too weak in SMA B (64.75%) and SMA C (68.05%). Based on the Suganda et al. (2022), students' critical thinking on waves was low, with correct responses below 50%. Basic skills were the strongest aspect, while providing simple explanations was the weakest. Efforts to enhance critical thinking skills are essential. Nainggolan et al. (2023) at SMAN 7 Bengkulu also reported low critical thinking on rotation dynamics. Reason (49.48%), inference (50.26%), situation (46.79%), clarity (47.74%), and overview (44.79%) were all classified as low. Thus, the findings underscore low critical thinking abilities among these students.

However, prior studies had limitations, including (1) focusing only on wave material and rotational dynamics, (2) using non-representative sample sizes, and (3) employing different critical thinking indicators. Given these limitations, further studies are needed to comprehensively analyze students' critical thinking abilities and determine their proficiency levels. This research aims to provide an overview of students' critical thinking skills at SMAN 5 Sidrap while studying the concept of Newton's Laws. It also seeks to determine whether students' critical thinking abilities improve after further analysis of their engagement with Newton's Laws material.

II. METHODS

This study employed a descriptive-quantitative research design, aiming to describe a situation by presenting numerical data to showcase research outcomes. The study was conducted to gather data on students' critical thinking abilities in problem-solving. This study was carried out at SMAN 5 Sidrap. The study took place during the even semester of the 2023/2024 academic year. The study utilized purposive sampling as the sampling technique. This technique involves selecting samples based on specific criteria relevant to the research objectives. The selected sample comprised students enrolled in physics classes. A total of 60 students from classes XI.1, XI.2, and XI.5 at SMAN 5 Sidrap were included in the sample.

The study followed these stages:

1. Preliminary studies
   Researchers consulted with the physics teacher to understand classroom conditions and conducted literature reviews to gather theories relevant to the research problem from sources such as scientific journals and books.
2. Creating instrument grids
   An instrument grid for a 40-item multiple-choice test was developed, with options labeled a, b, c, d, and e. Each question had one correct answer worth 1 point, and incorrect answers were scored 0. The test measured four aspects of critical thinking: interpretation, analysis, inference, and evaluation.
3. Test expert validity
   The critical thinking test was validated by two experts using the Gregory test method, as detailed below:

	Weak relevance (item worth 1 or 2)	Strong relevance (item worth 3 or 4)
Weak relevance (item worth 1 or 2)	A	B
Strong relevance (item worth 3 or 4)	C	D

Figure 1. Gregory test method

Information:

A = number of items in cell A (weak-weak relevance)
B = number of items in cell B (strong-weak relevance)
C = number of items in cell C (weak-strong relevance)
D = number of items in cell D (strong relevance

The internal consistency test equation used is as follows:

Consistency between experts:

$$(V) = \left[\frac{D}{A+B+C+D}\right] \quad 1)$$

Gregory's test requirements, if V ≥ 0.75 or ≥ 75% then it can be declared valid), from the expert test obtained a consistency value between experts (V) of 1 which indicates that the instrument is suitable for use in research (Gregory, 2014).

4. Reliability test

Following Sugiyono, (2017) reliability was assessed based on consistency in results over time. The reliability of the multiple-choice test was calculated using the following formula:

$$r_{11} = \left[\frac{n}{n-1}\right]\left[1 - \frac{Mt(n-Mt)}{nS_t^2}\right] \quad 2)$$

Information :

r_{11} = Instrument reliability
Mt = Mean total score
n = Number of items
1 = Constant number
S_t^2 = Total variance

Criteria $r_{11} > r_{tabel}$, then the instrument is reliable. The reliability classification of test questions is presented in the following table:

Table 1. Reliability categorization guidelines

Value interval criteria	Category
0.80 < r < 1.00	Very high
0.60 < r < 0.80	High
0.40 < r < 0.60	Medium
0.20 < r < 0.40	Low
0.00 < r < 0.20	Very low

5. Difficulty Level Analysis

The difficulty level of each question was analyzed to ensure an appropriate balance between easy and challenging items. The difficulty index was calculated using:

$$P = \frac{B}{Js} \quad 3)$$

Information:
P = Difficulty index
B = Number of students who answered correctly
Js = Number of test participants

Classification of the question difficulty index is as follows.

Table 2. Classification of question difficulty index

Difficulty index value	Category
0.00 – 0.30	Difficult
0.31 – 0.70	Medium
0.71 – 1.00	Easy

(Saputra et al., 2022)

Data collection technique

Data were collected using a multiple-choice critical thinking test administered to students. Each question corresponded to one of the four critical thinking indicators: interpretation, analysis, inference, or evaluation:

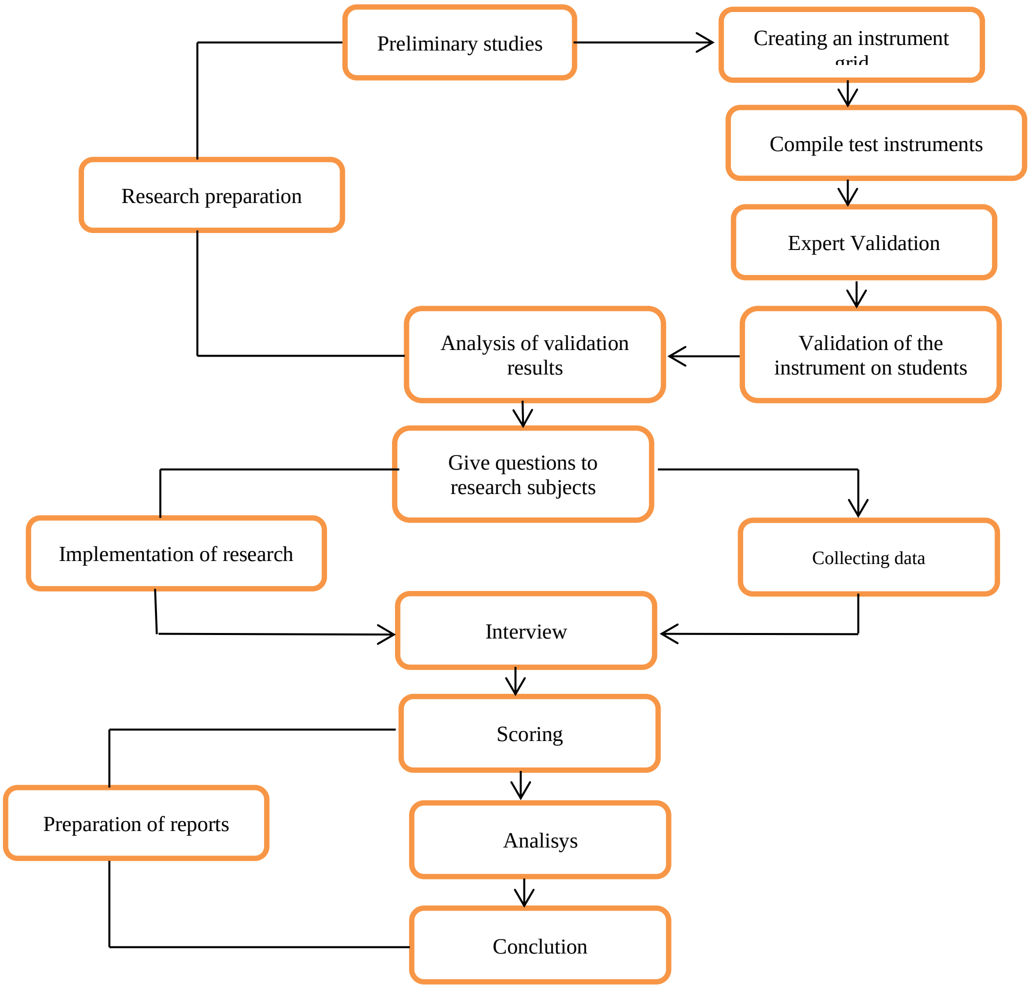

Figure 1. Research procedure

III. RESULTS AND DISCUSSION

This study involved 60 students from class XI at SMAN 5 Sidrap. The results of the critical thinking tests were analyzed and presented for four indicators: interpretation, analysis, inference, and evaluation. The findings are summarized as follows:

Overview of students' critical thinking abilities in general

The following provides an overview of students' performance across the four critical thinking indicators:

Table 3. Score of critical thinking ability on every indicator

Statistics	Statistical score			
	Interpretation	Analysis	Evaluation	Inference
Maximum score	9.00	4.00	9.00	9.00
Average	3.10	1.25	3.42	3.93
Variance	1.89	0.77	1.94	2.78
Standard deviation	1.37	0.88	1.39	1.37

Table 3 shows maximum scores of 9, 4, and 9 for the interpretation, inference, and evaluation indicators, respectively. The average scores for the four indicators were 3.10, 1.25, 3.42, and 3.93, respectively. This indicates that students performed better on inference indicators, while analysis indicators posed the most difficulty.

Table 4. Categorization score of critical thinking ability in general

Score intervals	Category	Frequency	Percentage (%)
28.00 – 34.99	Very high	0	0.00
21.00 – 27.99	High	0	0.00
14.00 – 20.99	Medium	19	31.67
7.00 – 13.99	Low	36	60.00
0.00 – 6.99	Very low	5	8.33
Amount		60	100.00

Table 4 reveals that 60.00% of students fell into the low category, indicating generally weak critical thinking skills among SMAN 5 Sidrap students. The general picture of students' critical thinking abilities is shown in the following diagram.

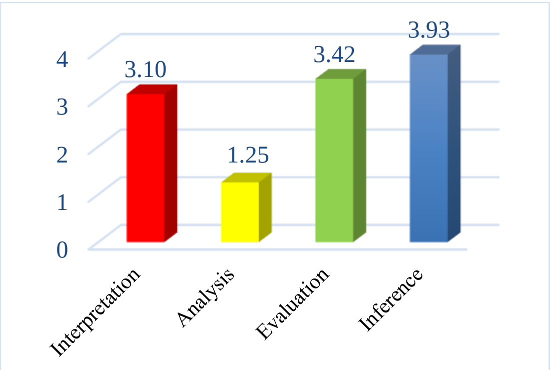

Figure 2. Description of critical think ability on every indicator

The average scores for the indicators were 3.1 for interpretation, 1.25 for analysis, 3.42 for evaluation, and 3.93 for inference. These results indicate that students at SMAN 5 Sidrap performed better on inference indicators, whereas analysis posed the most difficulty.

These findings were derived from the analysis of multiple-choice test answers collected earlier. The data came from 60 students in three classes who had studied Newton's Laws. A multiple-choice test was administered to assess students' critical thinking skills. From student feedback and school observations, it was evident that learning predominantly relied on the lecture method and teacher-centered approaches. This approach hindered students' ability to interpret visual information such as pictures, graphs, or tables.

Apart Additionally, low performance on interpretation indicators stemmed from limited practice with interpreting visual information. Observations revealed a lack of adequate teaching materials to support the enhancement of critical thinking skills. Teachers had not leveraged advancements in technology to develop e-modules equipped with multimedia elements (e.g., sound, animations, and interactive quizzes) that could enhance students' ability to interpret visual content.

Research by Suharyat et al. (2023) supports this finding, highlighting the effectiveness of e-modules in enhancing Indonesian students' critical thinking skills. Their study reported an effect size of 1.105, an average score of 77.5, a standard deviation of 0.23, and an N-gain of 0.66. The development of such e-modules could serve as a pivotal strategy for improving learning quality in Indonesia. Moreover, e-modules positively influence student learning outcomes.

The low performance on analysis indicators was attributed to the dominance of Low Order Thinking Skills (LOTS) questions and a lack of exposure to High Order Thinking Skills (HOTS) questions. This issue stems from students' reliance on memorization rather than problem-solving comprehension. LOTS questions are simpler and focus on recalling facts or identifying given information. In contrast, HOTS questions require more complex cognitive processes, such as analysis, evaluation, and conclusion-drawing. Therefore, incorporating HOTS questions into practice can train students to search for information, analyze it, and derive solutions. HOTS questions effectively foster critical thinking by promoting deeper analytical engagement.

Research by Putri et al. (2018) corroborates this study, demonstrating that HOTS questions enhance critical thinking, with analysis showing the greatest improvement, followed by interpretation, evaluation, and inference. The low performance on evaluation indicators was due to students' unfamiliarity with assessing the correctness of statements in problem-solving contexts. Additionally, teacher-centered instruction limited opportunities for students to process information independently. Learning activities will be meaningful if students are actively involved intellectually and socially through direct experience.

During the learning process, students are expected to engage directly with problems, investigate how processes work, and discover solutions independently. The evaluation indicator involves decisions to accept, reject, or question the truth of a given statement, which can be enhanced through experiential learning. Research by Arifah et al. (2021) supports this, showing that problem-based learning (PBL) connected to nature and the environment significantly enhances students' critical thinking skills in physics. This finding aligns with the research Ariani (2020), which revealed that students exposed to context-based problems rooted in real-world scenarios demonstrated better analytical reasoning and problem-solving abilities. In physics learning, especially on topics like Newton's Laws, integrating environmental and contextual elements into instructional strategies encourages students to relate abstract concepts to tangible experiences. This connection fosters deeper cognitive engagement and enhances their ability to interpret, analyze, and evaluate information effectively.

Critical thinking skills related to inference at SMAN 5 Sidrap remain underdeveloped due to an overemphasis on cognitive competence, resulting in limited opportunities for students to engage in practical activities. Practical activities are designed to promote active participation and enhance learning effectiveness. Such activities encourage logical thinking and problem-solving based on real-world scenarios through laboratory experiences. Practical sessions foster curiosity and enable students to actively acquire knowledge and information. An essential component of practicum activities is drawing conclusions from data analysis and conducted tests.

Research by Fadli et al. (2019) aligns with this, demonstrating that the problem-solving laboratory model significantly enhances students' critical thinking abilities by directly exposing them to physics concepts. Their study reported that the experimental class achieved higher critical thinking scores, averaging 65.25 compared to 49.2 in the control class. Furthermore, 70% of students in the experimental class demonstrated improved conclusion-making skills, compared to 58% in the control class.

A learning process dominated by teacher-centered lectures often renders students passive, depriving them of opportunities to develop independent discovery and critical thinking skills. Physics, as a study of natural phenomena, inherently requires active student participation in the learning process. Although teaching materials are used, they often remain monotonous, focusing solely on direct explanations without integrating student-centered activities. Thus, teachers should develop innovative teaching strategies that are engaging and foster critical thinking skills. Reasons for the reliance on lecture-based methods include time constraints for covering material within a semester, insufficient facilities and infrastructure, and a lack of student interest in learning.

The results of this study revealed the critical thinking abilities of SMAN 5 Sidrap students in Newton's Laws. Among the four indicators interpretation, analysis, evaluation, and inference the analysis indicator had the lowest score, while inference scored the highest. These findings can serve as a reference for teachers, helping them design and implement instructional strategies that enhance critical thinking skills, particularly in analysis.

IV. CONCLUSION AND SUGGESTION

Based on this study, the following conclusions were drawn regarding the critical thinking abilities of students at SMAN 5 Sidrap: (1) The interpretation indicator predominantly fell into the low category, with 53.33% of students demonstrating weak performance; (2) The analysis indicator also fell in the low category, with 38.33% of students scoring poorly; (3) The evaluation indicator was categorized as low, with 43.33%

of students performing inadequately; (4) The inference indicator scored in the medium category, with 46.67% of students showing moderate performance. A key factor contributing to students' poor critical thinking skills is the lack of regular exposure to questions designed to assess and enhance these abilities. Thus, adopting learning models that actively engage students in critical thinking practice is essential.

This study provides insights into students' critical thinking abilities in physics learning, specifically on the topic of Newton's Laws. However, several limitations should be addressed in future research. First, the study focused only on Newton's Laws, and future studies should explore other physics topics, such as rotational dynamics, waves, or optics, to gain a broader understanding of critical thinking skills across different contexts. Second, the sample was limited to one school, which restricts the generalizability of the findings; subsequent research should involve larger and more diverse samples from multiple schools. Third, the data collection relied on multiple-choice tests, and future studies could incorporate additional instruments, such as interviews, project-based assessments, or observation sheets, to provide a more comprehensive analysis.

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