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Analysis of Students' Critical Thinking Skills in Dynamic Fluid Concepts at MA Al-Azhar Center

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ABSTRACT

This study aims to analyze the critical thinking skills of eleventh-grade students at MA Al-Azhar Center Baturaja on dynamic fluid concepts based on the critical thinking indicators proposed by Robert H. Ennis. The research employed a descriptive quantitative approach using a saturated sampling technique, involving 30 students as the research subjects. The instrument used was a multiple-choice test consisting of 15 items covering seven critical thinking sub-indicators adapted from Ennis' critical thinking framework, namely problem formulation, argumentation, deduction, interpretation, induction, evaluation, and decision-making and implementation. Data were collected after the completion of the learning process and analyzed descriptively by calculating the percentage of achievement for each indicator. The results indicate that students' critical thinking skills are in the moderate category and are not evenly distributed across all indicators. The highest achievement was found in the induction indicator (58.33%), while the lowest was in problem formulation (33.33%). Other indicators, such as argumentation (51.67%), deduction (46.67%), interpretation (41.67%), evaluation (53.33%), and decision-making and implementation (52.22%), were also categorized as moderate. These findings suggest that students still experience difficulties in the initial stages of critical thinking, particularly in understanding and interpreting problems. Therefore, more comprehensive instructional strategies that emphasize the development of critical thinking skills are needed to optimally improve students' abilities.

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1. INTRODUCTION

Critical thinking skills are essential competencies that must be developed in physics learning at the senior high school level. Critical thinking in physics includes the ability to interpret information, analyze concepts, evaluate the application of physical laws, and draw logical conclusions (Rohmah et al., 2025). Critical thinking consists of several major dimensions, including Elementary Clarification, Basic Support, Inference, Advanced Clarification, and Strategy and Tactics. In this study, these dimensions were operationalized into seven measurable critical thinking sub-indicators, namely problem formulation, argumentation, deduction, interpretation, induction, evaluation, and decision-making and implementation (Suryo, 2023). Mastery of these indicators is important to train students in reasoning processes and concept-based decision-making (Igut et al., 2019).

However, students' critical thinking skills remain a challenge in physics learning in various schools (Sulbiana et al., 2024). This condition is often caused by learning practices that are still

oriented toward problem-solving and formula application, resulting in students being less trained in engaging in deep critical thinking processes.

One of the topics that requires strong critical thinking skills is dynamic fluids. This topic involves the interrelation of several physical variables, such as flow velocity, pressure, and cross-sectional area (Ilema et al., 2024). Understanding dynamic fluids requires analytical and evaluative skills toward contextual fluid flow phenomena (Amin Mustajab, 2024). Studies have shown that students often experience difficulties in understanding dynamic fluids conceptually (Nofi et al., 2018), making it important to map students' critical thinking skills in this topic.

Several previous studies have examined students' critical thinking skills in dynamic fluids. Affandy, Aminah, & Supriyanto (2019) found that students' critical thinking skills were still relatively low across several indicators. Suryo (2023) emphasized the importance of using valid instruments to map students' critical thinking profiles. Other studies also indicate that students' critical thinking skills in dynamic fluids fall within the moderate to low categories (Siburian et al., 2022). Some studies have focused on improving critical thinking skills through the implementation of specific learning models, such as problem-based learning (Zulaiha et al., 2019). Sulisworo & Kaliappen (2021) reported that STEM-based learning can enhance critical thinking skills. Ilema et al. (2024) demonstrated that the Think-Pair-Share model has a positive effect on students' critical thinking skills. However, these studies have not specifically focused on mapping students' critical thinking skills as an initial condition.

Based on the literature review, several limitations can be identified in previous studies on students' critical thinking skills in dynamic fluid concepts. Most prior studies have focused on examining the effectiveness of instructional interventions, such as Problem-Based Learning (Zulaiha et al., 2019), STEM-based learning (Sulisworo & Kaliappen, 2021) and Think-Pair-Share (Ilema et al., 2024), in improving students' critical thinking skills. As a result, limited attention has been given to investigating students' actual critical thinking profiles before instructional intervention. In addition, previous studies generally reported students' critical thinking skills at a general level (Youllanda et al., 2020) without providing a detailed analysis of each critical thinking sub-indicator. Consequently, teachers often lack diagnostic information regarding which specific aspects of critical thinking require further improvement.

The novelty of this study lies in three main aspects. First, this study provides a detailed mapping of students' critical thinking skills based on seven critical thinking sub-indicators adapted from Ennis' critical thinking framework (Ennis, 2011), namely problem formulation, argumentation, deduction, interpretation, induction, evaluation, and decision-making and implementation. This approach enables a more comprehensive identification of students' strengths and weaknesses in each measured aspect. Second, unlike previous studies that primarily emphasized the effectiveness of learning models (Farah et al., 2024), this study focuses on diagnosing students' actual critical thinking conditions as baseline data for instructional planning. Third, this study applies a sub-indicator-based descriptive analysis approach, allowing a deeper examination of students' achievement patterns across each aspect of critical thinking in dynamic fluid concepts. The findings are expected to provide contextual evidence and practical implications for improving physics instruction at MA Al-Azhar Center Baturaja.

2. METHODS

This study employed a descriptive quantitative approach aimed at describing the actual condition of students' critical thinking skills without applying any specific treatment or intervention. This approach was chosen as it aligns with the research objective, which is to map the profile of students' critical thinking skills based on Ennis' indicators proportionally across each sub-indicator (AIYESI, 2022). The study was conducted in the second semester of the 2025/2026 academic year at MA Al-Azhar Center Baturaja. This location was purposively selected because no similar study had previously been conducted there; therefore, the findings are expected to provide meaningful contributions to improving the quality of physics learning in the school.

The research subjects consisted of all eleventh-grade students at MA Al-Azhar Center Baturaja who participated in learning the dynamic fluid topic during the second semester of the 2025/2026 academic year, totaling 30 students. The subjects were selected using a saturated

sampling technique (total sampling), in which all members of the population were included as research subjects due to the limited and manageable population size (Sugiyono, 2020).

Data were collected using a critical thinking skills test consisting of 15 multiple-choice items. The instrument was developed based on Ennis' critical thinking framework (Ennis, 2011). The framework was operationalized into seven measurable critical thinking sub-indicators, namely problem formulation, argumentation, deduction, interpretation, induction, evaluation, and decision-making and implementation. These sub-indicators were selected to represent students' critical thinking performance within the context of dynamic fluid concepts.

The distribution of test items across the seven critical thinking sub-indicators was determined based on the relevance of each indicator to the dynamic fluid concepts and the limited number of items available in the instrument. Consequently, the number of items representing each sub-indicator was not equally distributed. Some indicators, such as evaluation, were represented by only one item. Therefore, the findings of this study should be interpreted as a preliminary diagnostic profile of students' critical thinking skills rather than a comprehensive assessment of each critical thinking dimension. This limitation is consistent with previous studies indicating that critical thinking is a multidimensional construct and that a limited number of items may not fully capture the complexity of each critical thinking component (Payan-carreira *et al*., 2022). Furthermore, diagnostic assessments are primarily intended to provide an initial mapping of students' strengths and weaknesses rather than an exhaustive evaluation of all sub-skills (Walsh *et al*., 2019). The results are intended to provide an initial overview of students' strengths and weaknesses across the measured sub-indicators and may serve as baseline information for future studies employing more extensive instruments. The distribution of test items across the seven sub-indicators is presented in Table 1.

Table 1. Distribution of Test Items Based on Critical Thinking Sub-Indicators

Critical Thinking Sub-Indicators	Item Numbers
Problem Formulation	1–2
Argumentation	3–4
Deduction	5–7
Interpretation	8–9
Induction	10–11
Evaluation	12
Decision-Making and Implementation	13–15
Total	15 Items

The instrument used in this study consisted of 15 multiple-choice items developed based on critical thinking indicators and dynamic fluid concepts. Prior to administration, the instrument underwent expert judgment validation involving physics education experts to ensure the relevance, clarity, and suitability of each item with the intended constructs (Ariani, 2020). As this study aimed to provide an initial descriptive profile of students' critical thinking skills, the instrument was employed as a content-validated diagnostic tool. The test was administered after the completion of the dynamic fluid learning process. Each correct response was scored as 1, while incorrect responses were scored as 0 (Azmi *et al*., 2022). The total scores obtained by students were subsequently converted into percentages of achievement for each critical thinking indicator.

The data were analyzed descriptively using Microsoft Excel to calculate the frequency of correct responses, the percentage of achievement for each item, and the percentage of achievement for each critical thinking indicator. Descriptive statistical analysis was considered appropriate because the objective of the study was to identify and describe students' critical thinking profiles rather than to test hypotheses or determine causal relationships (Candra Susanto *et al*., 2024). The results were then presented in the form of tables and graphs to facilitate the interpretation of students' achievement levels across the measured indicators (Rasmi *et al*., 2025). Students' achievement percentages were calculated using the following formula:

$$P = \frac{\text{Score Obtained}}{\text{Maximum Score}} \times 100\% \quad (1)$$

Data were analyzed descriptively by calculating the percentage of achievement for each critical thinking sub-indicator based on students' correct responses. The percentage scores were then classified into three levels of critical thinking achievement high, moderate, and low to facilitate the interpretation of the findings. The classification criteria were adapted from Youllanda *et al*. (2020), in which achievement scores of 70% or above were categorized as high, scores between 40% and 69% as moderate, and scores below 40% as low. These categories were used solely as descriptive criteria to interpret students' achievement levels rather than as normative standards. The classification criteria applied in this study are presented in Table 2.

Table 2. Criteria for Classifying Critical Thinking Skills

No.	Category	Percentage Range
1	High	≥ 70%
2	Moderate	40% – 69%
3	Low	< 40%

Source: Youllanda *et al*., 2020

3. RESULT AND DISCUSSION

The instrument consisted of 15 multiple-choice questions designed to assess students' critical thinking skills in dynamic fluid concepts. Referring to the critical thinking framework proposed by Ennis, (2011) and its operationalization in previous studies (Aswanti & Isnaeni, 2023), the instrument employed seven measurable sub-indicators, namely problem formulation, argumentation, deduction, interpretation, induction, evaluation, and decision-making and implementation. These sub-indicators were used to represent various aspects of critical thinking within the context of this study.

The students' responses were analyzed descriptively by calculating the number of correct responses, the percentage of correct answers for each item, and the percentage of achievement for each critical thinking sub-indicator. Since the instrument consisted of a limited number of items, the distribution of questions across the seven sub-indicators was not balanced. Consequently, the results should be interpreted as an initial profile of students' performance on the measured aspects of critical thinking rather than as a comprehensive assessment of each sub-indicator. The analysis results are presented in Table 3.

Table 3. Analysis of Students' Response Results

Critical Thinking Sub-Indicator	Item Number	Number of Correct Responses	Percentage per Item	Percentage per Sub-Indicator
Problem Formulation	1	9	30%	33,33%
	2	11	36,67%	
Argumentation	3	15	50%	51,67%
	4	16	53,33%	
Deduction	5	15	50%	46,67%
	6	17	56,67%	
	7	10	33,33%	
Interpretation	8	16	53,33%	41,67%
	9	9	30%	
Induction	10	18	60%	58,33%
	11	17	56,67%	
Evaluation	12	16	53,33%	53,33%
Decision-Making and Implementation	13	23	76,67%	52,22%
	14	12	43,33%	
	15	12	40%	

These results indicate that students' critical thinking skills were not evenly distributed across the measured sub-indicators, with considerable variation in achievement levels. The lowest achievement was found in the problem formulation indicator (33.33%), suggesting that students experienced difficulties in identifying and understanding the essential problems presented in the questions. This finding is consistent with previous studies showing that students often encounter challenges during the initial stages of critical thinking, particularly in recognizing and formulating problems before attempting to solve them (Egi, 2020) .

The argumentation indicator reached 51.67%, indicating that students had begun to demonstrate reasoning skills, although these abilities were not yet consistently exhibited. Similarly, the deduction indicator achieved 46.67%, suggesting that students still experienced difficulties in applying general concepts to specific situations and drawing logical conclusions. These findings are in line with Hikmah *et al.*, (2023) who reported that students require more opportunities to engage in reasoning and contextual problem-solving activities.

The interpretation indicator obtained 41.67%, indicating that many students still encountered difficulties in interpreting information and relating physical concepts to observed phenomena. This finding supports previous research showing that limited conceptual understanding often prevents students from accurately interpreting physics problems (Bahsoan *et al*., 2025). In contrast, the induction indicator recorded the highest achievement (58.33%), suggesting that students were relatively more successful in drawing conclusions from the information provided.

The evaluation indicator achieved 53.33%, while the decision-making and implementation indicator reached 52.22%, both of which fall within the moderate category. However, the evaluation result should be interpreted with caution because this sub-indicator was represented by only one test item. As explained in the Methods section, the unequal distribution of items resulted from the limited number of items available in the instrument and their relevance to the dynamic fluid concepts. Although the item was developed to assess students' ability to evaluate evidence and make judgments within the context of dynamic fluid concepts, the use of only one item limits the comprehensiveness of the evaluation measurement because critical thinking is a multidimensional construct. Therefore, the reported percentage should be regarded as a preliminary diagnostic indication rather than a comprehensive measure of students' evaluation ability. Future studies are recommended to include multiple items for each critical thinking sub-indicator to improve the validity and reliability of the assessment (Aliyah, 2025).

Overall, these findings suggest that students demonstrated moderate performance across most critical thinking sub-indicators, with the greatest difficulties observed in problem formulation and interpretation. To provide a clearer overview of students' responses to each test item, the results are further illustrated in Figure 1.

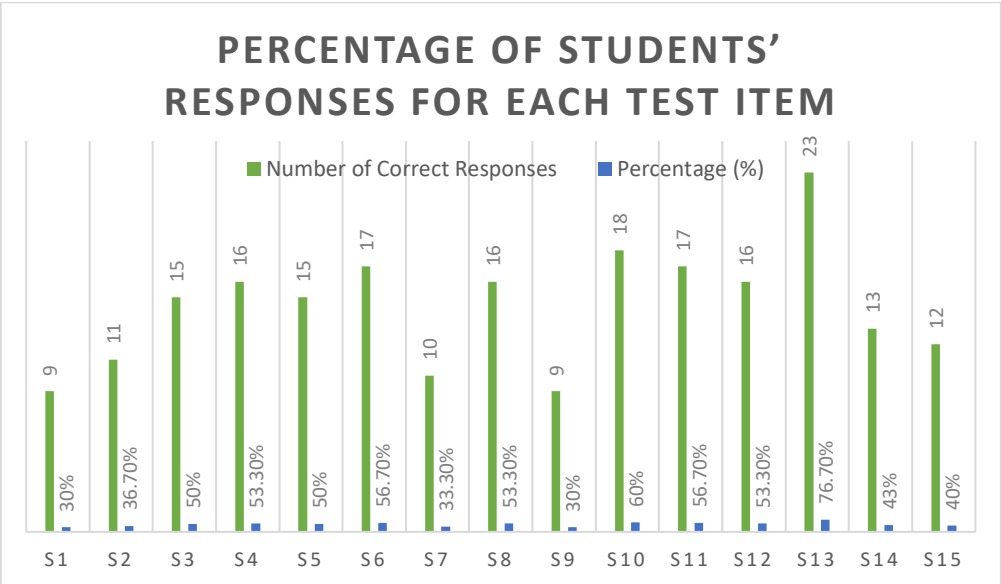


Figure 1. Analysis Results and Percentage of Students' Responses for Each Test Item

Based on Figure 1, it can be observed that the percentage of students' correct responses for each item shows considerable variation. The highest percentage is found in item number 13, with 76.67%, which belongs to the decision-making and implementation indicator. This may be because decision-making questions are more familiar to students as they often involve direct application rather than complex analysis to answer questions related to decision-making processes.

In contrast, the lowest percentages are found in items number 1 and 9, both at 30%, which are associated with the problem formulation and interpretation indicators. This finding reinforces the previous results that students still experience difficulties in the early stages of critical thinking, particularly in understanding and interpreting the given problems. To obtain a more comprehensive overview of students' critical thinking achievement across each sub-indicator, the data are further presented in graphical form in Figure 2.

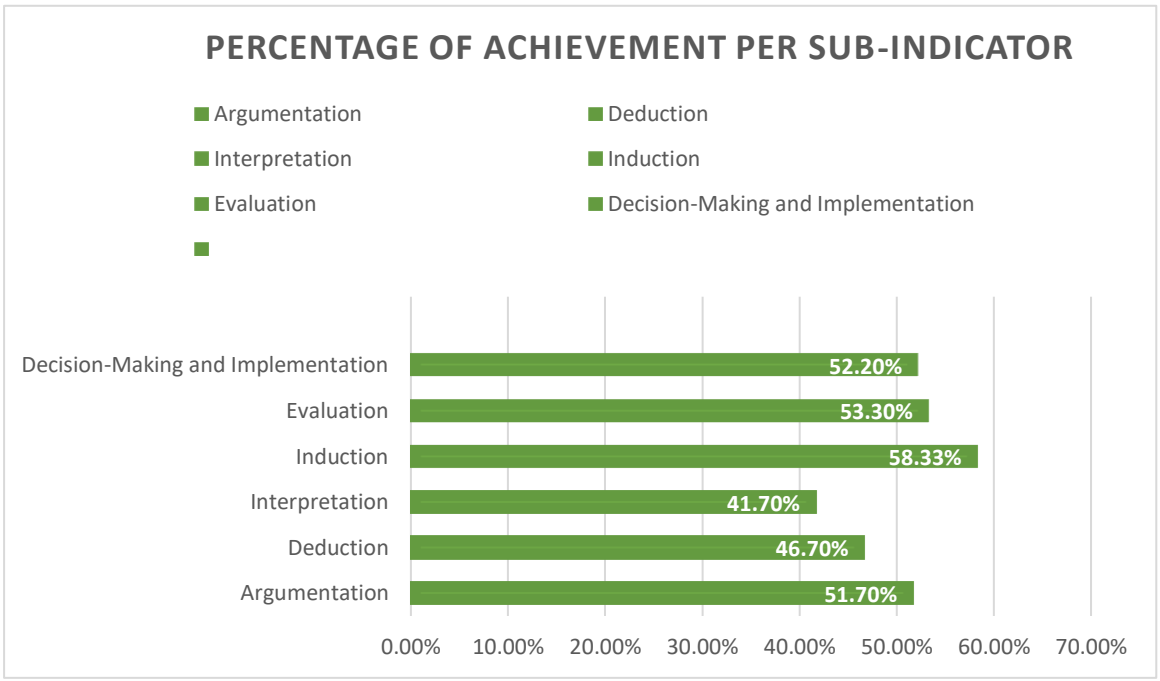


Figure 2. Percentage of Achievement per Sub-Indicator

Based on Figure 2, it can be observed that the level of students' critical thinking achievement across each sub-indicator remains in the moderate category and has not yet reached optimal levels. This indicates that students' critical thinking skills have not developed evenly across all indicators. The highest percentage is found in the induction indicator at 58.33%, while the lowest is in problem formulation at 33.33%. In addition, the interpretation and deduction indicators also show relatively lower achievement compared to other indicators.

The low achievement in the problem formulation indicator indicates that most students still experience difficulties in understanding and identifying the core of the given problems. Students tend to attempt answering questions without fully comprehending what is being asked (Egi, 2020). In fact, problem formulation is a crucial initial step in the critical thinking process, as it determines the direction of subsequent problem-solving (Fauziah, 2024).

Similarly, the results for the interpretation indicator are not yet optimal. This suggests that students still face difficulties in interpreting the information presented, whether in the form of concepts or physical phenomena (Muttakin, 2024). This condition indicates that students' understanding of dynamic fluid concepts is not yet sufficiently deep. This finding suggests that students' conceptual understanding of dynamic fluid concepts may not yet be sufficiently developed. Previous studies have reported that students often experience difficulties in relating formulas to the underlying physical concepts, which may affect their ability to interpret information and phenomena

correctly (Nofi et al., 2018). As a result, students are less accustomed to connecting the information they obtain with its actual meaning within a given problem.

In the deduction indicator, students' ability to draw conclusions from general concepts to more specific situations remains at a moderate level. For the indicators of argumentation, evaluation, and decision-making and implementation, the results indicate that students have begun to demonstrate the ability to justify answers, evaluate information, and make decisions. However, these performances have not yet reached optimal levels, suggesting that further development of higher-order thinking skills is still needed (Marisda et al., 2024). In the deduction indicator, students' ability to apply general concepts to specific situations remained at a moderate level, indicating that students still experienced challenges in performing logical reasoning and drawing conclusions systematically (Suryo, 2023).

On the other hand, the induction indicator shows the highest achievement among all indicators. This suggests that students are relatively more capable of drawing conclusions from given data or examples. The induction indicator showed the highest achievement (58.33%), indicating that students demonstrated relatively better performance in drawing conclusions based on the information provided. This finding suggests that students were more successful in identifying patterns and deriving conclusions from given data or cases (Amin Mustajab, 2024).

For the indicators of argumentation, evaluation, and decision-making and implementation, the results fall within the moderate category. This indicates that students have begun to develop the ability to justify their answers, evaluate available information, and make decisions (Marisda *et al*., 2024). The results indicate that students still encountered difficulties in applying general concepts to specific situations.

The findings indicate that students' achievement varied across the measured critical thinking sub-indicators, suggesting differences in performance among the assessed aspects. However, these findings should be interpreted with caution, as they were derived solely from students' responses to a multiple-choice test administered after the completion of the learning process (Paramitha & Sriyanti, 2021). Therefore, the results provide only an initial profile of students' performance on the measured indicators and do not fully represent the complexity of students' critical thinking processes (Halmaida, Elmi Mahzum, 2020).

This study has several limitations. First, the study involved only 30 students from a single school, which may limit the generalizability of the findings. Second, the analysis was restricted to descriptive statistics without inferential analysis. Third, the instrument was validated through expert judgment to establish content validity, whereas empirical reliability testing and comprehensive psychometric analyses were not conducted. In addition, item characteristics such as difficulty index, discrimination power, and distractor effectiveness were not examined (Affandy *et al*., 2019). Furthermore, the distribution of items across the critical thinking sub-indicators was uneven, with the evaluation indicator represented by only one item. Since the findings were obtained exclusively from a multiple-choice test, they do not capture students' critical thinking processes in depth (Ariani, 2020). Consequently, the results should be interpreted as an initial diagnostic profile rather than a comprehensive assessment of students' critical thinking skills (Dariah *et al.*, 2024). Future studies are recommended to employ multiple sources of evidence, such as interviews, classroom observations, document analysis, or think-aloud protocols, and to develop instruments with stronger psychometric properties to obtain a more comprehensive understanding of students' critical thinking skills.

Despite these limitations, the present findings are generally consistent with previous studies reporting that students' critical thinking skills in dynamic fluid concepts remain at a moderate level (Sulbiana, Haris & Yani, 2024). Therefore, further efforts are needed to support the development of critical thinking skills in physics learning. Future studies may explore the effectiveness of instructional approaches, such as Problem-Based Learning, in fostering students' critical thinking skills (Farah *et al*., 2024).

4. CONCLUSION

Based on the analysis of the seven critical thinking sub-indicators adapted from Ennis' framework, it can be concluded that the critical thinking skills of eleventh-grade students at MA Al-

Azhar Center Baturaja on dynamic fluid concepts remain at a moderate level and are not evenly distributed across all measured sub-indicators. The highest achievement was observed in the induction indicator, whereas the lowest achievement was found in problem formulation, indicating variations in students' performance across different aspects of critical thinking. These findings support the view that critical thinking is a multidimensional construct in which the development of one aspect does not necessarily imply similar development in other aspects.

From a pedagogical perspective, these findings highlight the importance of providing students with learning experiences that encourage problem analysis, information interpretation, reasoning, and the evaluation of alternative solutions. Therefore, meaningful learning activities that engage students in higher-order thinking processes are needed to support the development of critical thinking skills in physics learning. Considering that the present study relied solely on a multiple-choice test administered to a limited sample, the findings should be interpreted as an initial diagnostic profile of students' critical thinking skills. Future studies are recommended to involve larger samples, employ more comprehensive assessment approaches using multiple sources of evidence, and investigate the effectiveness of instructional approaches, such as Problem-Based Learning, in fostering students' critical thinking skills in physics learning.

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