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PROFILE OF MATHEMATICAL CRITICAL THINKING SKILLS OF VOCATIONAL HIGH SCHOOL STUDENTS BASED ON FACIONE INDICATORS IN STATISTICS

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ABSTRAK

Kemampuan berpikir kritis matematis menjadi kompetensi esensial dalam pembelajaran abad ke-21, terutama pada materi statistika yang menuntut analisis dan penalaran yang mendalam. Namun, berbagai temuan menunjukkan bahwa kemampuan tersebut pada siswa belum berkembang secara optimal dan masih menunjukkan ketidakseimbangan antar aspek berpikir. Penelitian ini bertujuan untuk mendeskripsikan profil kemampuan berpikir kritis matematis siswa kelas XI di SMK Negeri 4 Medan berdasarkan indikator berpikir kritis. Penelitian ini menggunakan pendekatan kualitatif dengan metode deskriptif. Subjek penelitian berjumlah 14 siswa yang dipilih secara purposif sesuai dengan konteks pembelajaran statistika. Data dikumpulkan melalui tes esai dan dianalisis menggunakan teknik deskriptif untuk menggambarkan capaian kemampuan siswa pada setiap indikator. Hasil penelitian menunjukkan bahwa kemampuan berpikir kritis matematis siswa berada pada kategori sedang dengan rata-rata capaian sebesar 57,1%. Kemampuan siswa cenderung lebih baik pada tahap memahami dan menganalisis masalah, sedangkan pada tahap mengevaluasi, menarik kesimpulan, dan menjelaskan alasan masih tergolong rendah. Temuan ini menunjukkan bahwa kemampuan berpikir kritis siswa belum berkembang secara menyeluruh pada seluruh tahapan berpikir. Oleh karena itu, diperlukan pembelajaran yang secara terarah mendorong aktivitas penalaran, refleksi, dan komunikasi matematis agar pengembangan kemampuan berpikir kritis dapat berlangsung secara lebih seimbang dan berkelanjutan.
Kata Kunci: *Berpikir Kritis Matematis, Indikator Facione, Statistika, Analisis Deskriptif*

ABSTRACT

Mathematical critical thinking skills have become an essential competency in 21st-century learning, particularly in statistics, which requires in-depth analysis and reasoning. However, various findings indicate that students' critical thinking skills have not yet developed optimally and still show imbalances across different aspects of thinking. This study aims to describe the profile of eleventh-grade students' mathematical critical thinking skills at SMK Negeri 4 Medan based on critical thinking indicators. The study employed a qualitative approach with a descriptive method. The participants consisted of 14 students selected through purposive sampling in accordance with the context of statistics learning. Data were collected using an essay-based test and analyzed through descriptive techniques to illustrate students' achievement across each indicator. The results show that students' mathematical critical thinking skills are at a moderate level, with an average achievement of 57.1%. Students tend to perform better in understanding and analyzing problems, while their abilities in evaluating, drawing conclusions, and explaining reasoning remain relatively low. These findings indicate that students' critical thinking skills have not yet developed comprehensively across all stages of thinking. Therefore,

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learning should be designed to systematically promote reasoning, reflection, and mathematical communication to support a more balanced and sustainable development of critical thinking skills.

Keywords: *Mathematical Critical Thinking, Facione Indicators, Statistics, Descriptive Analysis.*

INTRODUCTION

Education in the 21st century emphasizes the development of higher-order thinking skills that extend beyond mere content mastery. Students are expected to engage in analytical reasoning, evaluate information critically, and make well-founded decisions across various contexts. The rapid growth of science and technology further reinforces the need for learners to process information in a logical and reflective manner. In mathematics education, these demands are particularly significant because learning mathematics involves not only procedural computation but also structured reasoning processes. Therefore, strengthening students' mathematical critical thinking skills has become a central concern in efforts to improve educational quality, especially in contexts that require analytical competence such as statistics learning in vocational schools.

Mathematical critical thinking skills contribute substantially to students' ability to comprehend problems holistically and formulate systematic solution strategies. Learners who possess strong critical thinking abilities are generally more capable of identifying relevant information, assessing the validity of procedures, and generating logical conclusions (Darmawan & Warmi, 2022). Moreover, these skills enable students to relate mathematical concepts to real-world situations, thereby enhancing the meaningfulness of learning experiences (Maghfiroh & Dasari, 2023). In this regard, critical thinking not only affects academic achievement but also strengthens the overall quality of students' reasoning processes. Consequently, the integration of critical thinking into mathematics instruction becomes an essential component of effective learning.

Despite its importance, empirical studies consistently reveal that students' mathematical critical thinking skills remain underdeveloped. Many learners encounter difficulties when required to perform deeper analysis or justify their reasoning logically (Sutarni & Gatiningsih, 2022). In statistics learning specifically, students often prioritize procedural calculations without adequately interpreting the meaning of the data they analyze (Suryani & Haryadi, 2022). This condition indicates a clear discrepancy between the expected outcomes of critical thinking-oriented instruction and the actual practices observed in classrooms. Such findings highlight that the issue is not only theoretical but also evident in real learning situations, thereby reinforcing the urgency of addressing this problem.

The existence of this gap is further supported by research showing that mathematics instruction frequently emphasizes final answers rather than the thinking processes leading to those answers. As a result, students rarely engage in reflective activities such as evaluating or revising their solutions (Aritonang et al., 2024). Although various instructional innovations, including problem-based digital teaching materials, have been introduced to foster higher-order thinking, their implementation has not yet been consistently effective across different educational contexts (Nabilah & Siregar, 2023). This inconsistency suggests that existing approaches have not fully addressed students' needs in developing critical thinking skills. Therefore, a more focused and in-depth analysis of students' critical thinking profiles is required to better understand their actual cognitive conditions.

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In vocational education settings, particularly in vocational high schools (SMK), the challenge becomes more complex due to the dual demand for conceptual understanding and practical applicability. Students in these institutions are expected to develop thinking skills that are directly relevant to workplace contexts. However, research indicates that vocational students' mathematical critical thinking abilities are still relatively low, especially in higher-order reasoning aspects (Novita & Hidayati, 2022). At the same time, studies have demonstrated that structured learning interventions, such as modules based on mathematical logic, can effectively support the improvement of these skills (Baidowi et al., 2024). These findings suggest that appropriate instructional design plays a crucial role in facilitating the development of critical thinking in vocational contexts.

To analyze critical thinking skills more systematically, this study adopts the framework proposed by Facione, which consists of interpretation, analysis, evaluation, inference, and explanation. These indicators represent sequential stages of thinking processes involved in understanding and solving problems (Mastuti et al., 2022). The use of this framework allows for a more detailed and structured examination of students' abilities at each stage of reasoning (Nurkasanah & Sari, 2025). Furthermore, applying Facione's indicators provides a comprehensive basis for identifying specific strengths and weaknesses in students' critical thinking processes. Thus, this framework is considered highly relevant for investigating mathematical critical thinking skills in depth.

Statistics is selected as the focus of this research because it inherently requires students to interpret data, analyze relationships, and draw reasoned conclusions. In statistics learning, understanding the meaning behind numerical data is as important as performing calculations. Previous studies have shown that learning approaches based on Higher Order Thinking Skills (HOTS) can significantly enhance students' critical thinking abilities in statistical contexts (Indriyani, 2024). This makes statistics an appropriate domain for examining how students apply critical thinking in meaningful and contextualized situations. Therefore, focusing on statistics provides both theoretical relevance and practical significance for this study.

Based on these considerations, the novelty of this research lies in its specific focus on profiling vocational high school students' mathematical critical thinking skills in statistics using Facione's indicators. Unlike previous studies that tend to examine critical thinking in general contexts, this study integrates three key aspects simultaneously: vocational education settings (SMK), statistical content, and a detailed indicator-based analysis framework. This approach not only identifies the level of students' abilities but also reveals their strengths and weaknesses across each dimension of critical thinking. As a result, the findings are expected to provide more targeted insights for developing instructional strategies that emphasize thinking processes rather than merely outcomes. Accordingly, this study aims to describe the profile of mathematical critical thinking skills of Grade XI students at SMK Negeri 4 Medan based on the indicators of interpretation, analysis, evaluation, inference, and explanation.

RESEARCH METHOD

This study employed a qualitative approach with a descriptive design to describe the profile of students' mathematical critical thinking skills in statistics. The research participants consisted of 14 eleventh-grade students from the Industrial Electronics Engineering (TEI) program at SMK Negeri 4 Medan. The subjects were selected using purposive sampling based on specific criteria, namely students who had studied or were currently studying statistics material relevant to the test. The study was conducted in a natural classroom setting without

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any treatment, so that the data obtained reflected students' actual abilities during regular learning activities.

The research instrument was an essay-based mathematics test developed based on five indicators of critical thinking skills: interpretation, analysis, evaluation, inference, and explanation. The instrument development process included preparing a test blueprint, constructing questions according to the statistics material, and conducting expert validation to ensure the appropriateness of the content and clarity of the items. Students' responses were assessed using an analytic scoring rubric with a score range of 0–4 for each indicator based on the quality of their answers. The total score for each student was calculated by summing all indicator scores and then converted into percentage form to determine the level of mathematical critical thinking skills.

The research procedure was carried out through several stages, namely instrument preparation, validation, test administration, scoring, and data analysis. The test results were analyzed using descriptive statistical techniques to obtain an overview of students' critical thinking skill profiles across each indicator. The analysis results were then interpreted using predetermined criteria to classify students' abilities into several categories. The classification of critical thinking skill levels used in this study is presented in Table 1.

Table 1. Criteria of Critical Thinking Skills

Score Interval (%)	Category
86–100	Very High
71–85	High
56–70	Moderate
41–55	Low
< 40	Very Low

RESULT AND DISCUSSION

Result

The results of this study were obtained through descriptive statistical analysis to describe students' mathematical critical thinking skills based on five indicators: interpretation, analysis, evaluation, inference, and explanation. The data analyzed include mean, median, standard deviation, minimum score, and maximum score to show the distribution of students' abilities. The findings are presented in tabular form to provide a clear and structured overview of the data. A summary of the descriptive statistics is presented in Table 2.

Table 2. Descriptive Statistics of Students' Critical Thinking Skills

Indicator	Mean	Median	SD	Min	Max
Interpretation	9.93	10.5	2.09	6	12
Analysis	8.93	8.00	1.98	6	12
Evaluation	6.21	6.50	4.21	0	12
Inference	5.64	6.50	3.77	0	11
Explanation	3.57	4.00	3.08	0	8
Percentage (%)	57.1	55.9	20.2	28.3	86.7

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Table 2 shows that the highest mean score is found in the interpretation indicator (9.93), followed by analysis (8.93). Lower mean scores appear in evaluation (6.21), inference (5.64), and explanation (3.57). The minimum score of 0 is observed in several indicators, while the maximum scores vary across indicators. The overall percentage of students' critical thinking skills is 57.1%, indicating the general level of achievement.

To complement the tabular data, the mean scores of each indicator are also presented in graphical form to show differences in achievement more clearly. The graph is used to display variations in average scores across all indicators. The visualization of these results is presented in Figure 1.

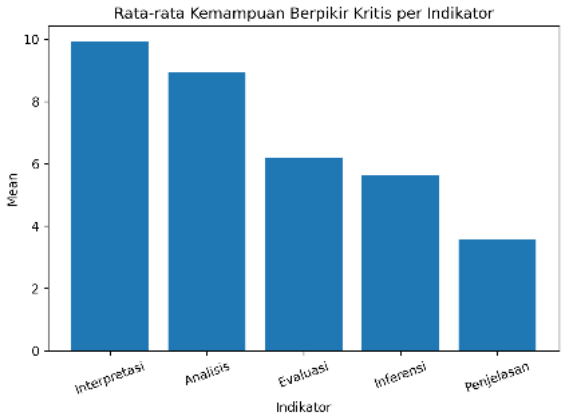

Figure 1. Average Scores of Students' Critical Thinking Skills Across Indicators

Figure 1 illustrates the comparison of mean scores across the five indicators. The interpretation and analysis indicators appear at higher positions compared to the others. Meanwhile, evaluation, inference, and explanation show lower mean values. The graph also shows a gradual decrease in scores from the first indicators to the later ones.

Based on Table 2 and Figure 1, the distribution of students' scores varies across indicators. The difference between minimum and maximum scores indicates variation in students' performance levels. Some indicators show wider score ranges than others, reflecting differences in achievement among students. Overall, the results describe the profile of students' mathematical critical thinking skills based on the measured indicators.

Discussion

The findings demonstrate that students' mathematical critical thinking skills have not yet developed evenly across all indicators, as reflected in the contrast between higher performance in initial stages and lower achievement in advanced stages. This pattern indicates an imbalance in the progression of students' thinking processes, where foundational understanding is more established than higher-level reasoning. Within the framework of critical thinking, this condition suggests that students are still concentrated at the stages of interpreting and processing information rather than advancing toward evaluative and reflective thinking. Similar patterns have been identified in prior studies, which collectively show that students tend to perform better in early cognitive stages but encounter challenges when engaging in more complex reasoning processes (Anggraini et al., 2022). These converging findings reinforce the

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notion that the development of critical thinking is often uneven and requires targeted instructional support.

The relatively strong performance in the interpretation indicator indicates that students are able to recognize and understand the information presented in statistical problems. This ability reflects the initial stage of critical thinking, where individuals identify relevant elements before proceeding to deeper analysis. However, when viewed alongside findings from other studies, it becomes evident that comprehension alone does not automatically lead to higher-level reasoning, as students often struggle to extend their understanding into more complex analytical processes (Yuliatin et al., 2024). In the context of statistics learning, this limitation may be related to students' tendency to focus on surface-level information rather than exploring underlying data relationships. Therefore, while the interpretation stage appears to be relatively well developed, it has not yet been fully integrated into a comprehensive critical thinking process.

In the analysis indicator, students demonstrate an adequate ability to break down information and identify relationships between given data. This suggests that they are capable of organizing problem elements and determining procedural steps required for solving tasks. Nevertheless, when these findings are considered together with previous research, it can be inferred that students' analytical skills are still largely procedural rather than reflective in nature (Tama & Setyadi, 2022). This indicates that students may recognize relationships between concepts but have not yet optimized their ability to use these relationships for deeper reasoning. In vocational education settings, such as SMK, this tendency may be influenced by learning practices that emphasize task completion and procedural accuracy over conceptual exploration.

In contrast, the evaluation indicator reveals that students experience considerable difficulty in assessing the correctness of their procedures and results. This reflects limitations in metacognitive aspects of thinking, particularly in monitoring and reviewing one's own reasoning process. When compared with existing studies, it becomes apparent that this issue is not isolated, as many students are not accustomed to critically examining their solutions or identifying potential errors independently (Tutuarima et al., 2024). The absence of reflective evaluation practices suggests that learning environments may not sufficiently encourage students to question or justify their answers. As a result, evaluation skills remain underdeveloped despite students' ability to perform initial analytical steps.

The inference indicator further shows that students encounter challenges in formulating logical conclusions based on the available data. Drawing conclusions requires the integration of multiple pieces of information into a coherent reasoning structure, which represents a higher stage in the critical thinking process. The relatively low performance in this indicator aligns with findings indicating that vocational students often struggle to construct precise and well-supported conclusions (Novita & Hidayati, 2022). This suggests that students' reasoning processes have not yet reached a level where they can systematically synthesize information into valid conclusions. In the context of statistics, this limitation may hinder students' ability to interpret data meaningfully and make informed decisions.

The explanation indicator records the lowest level of achievement, indicating that students have difficulty articulating their reasoning in a clear and structured manner. The ability to explain is closely related to the organization and clarity of thought, as it requires students to communicate their reasoning logically. Findings from previous studies consistently highlight that explanatory skills remain one of the weakest aspects of students' mathematical thinking (Rahmawati & Rizaldi, 2025). When viewed collectively, these results suggest that although students may partially understand and analyze problems, they struggle to externalize their

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thinking processes effectively. This limitation is particularly significant in mathematics learning, where clear communication of reasoning is essential for demonstrating understanding.

Overall, the observed decline from interpretation to explanation indicates that learning practices are still predominantly oriented toward procedural mastery rather than the development of comprehensive critical thinking skills. When synthesized with prior research, it becomes evident that the transition from lower-order to higher-order thinking requires structured learning strategies that explicitly promote analysis, evaluation, and reflection (Zana et al., 2022). In addition, approaches that integrate project-based learning and STEM have been shown to provide meaningful contexts that support the development of deeper thinking processes (Pramasdyahsari et al., 2023; Rizky, 2024). In vocational education, such approaches are particularly relevant because they align with the need for practical and applied thinking skills. Therefore, the findings of this study reinforce the importance of shifting instructional focus toward activities that engage students in higher-order cognitive processes.

The implications of this study highlight that the development of critical thinking skills must be carried out in an integrated and systematic manner across all indicators. Instructional practices need to move beyond emphasizing correct answers and instead focus on fostering reasoning, reflection, and communication skills. When considered alongside previous studies, it can be concluded that the use of assessment instruments designed to target higher-order thinking, as well as interactive and student-centered learning strategies, can contribute to improving these abilities (Rahmawati et al., 2022; Kosasih, 2022). In the specific context of vocational schools and statistics learning, this means designing activities that require students to interpret data, evaluate results, and explain their reasoning explicitly. Through such efforts, the development of mathematical critical thinking skills can be achieved more comprehensively and sustainably.

CONCLUSION

This study successfully describes the profile of mathematical critical thinking skills of eleventh-grade students in statistics based on five key indicators. The findings show that students' abilities are not evenly developed across all stages of thinking, with stronger performance in interpretation and analysis compared to evaluation, inference, and explanation. This imbalance indicates that students are still more familiar with procedural and surface-level reasoning than with deeper analytical and reflective processes. These results confirm that there is a discrepancy between the expected development of critical thinking skills and the actual conditions observed in classroom learning.

Furthermore, this study highlights that the development of mathematical critical thinking requires an integrated approach that addresses all components of thinking simultaneously. The findings emphasize that focusing only on early-stage skills is not sufficient to support the progression toward higher-order thinking. In this context, the novelty of this research lies in its specific examination of students' critical thinking profiles in vocational education settings, particularly in statistics learning, using indicator-based analysis. This approach provides a more detailed understanding of students' strengths and weaknesses across different dimensions of critical thinking. As a result, improving students' abilities in evaluation, inference, and explanation becomes a key priority for achieving balanced cognitive development.

In terms of practical implications, mathematics instruction needs to be designed to actively engage students in reasoning, reflection, and communication processes. Learning activities should not only emphasize obtaining correct answers but also encourage students to

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evaluate their thinking, construct logical conclusions, and explain their reasoning systematically. In addition, assessment practices should be aligned with higher-order thinking objectives to support the development of these skills. For future research, it is recommended to involve a larger and more diverse sample and to explore instructional interventions, such as problem-based or project-based approaches, that specifically target the improvement of higher-order thinking indicators. These efforts are expected to contribute to the development of more effective and sustainable strategies for enhancing students' mathematical critical thinking skills.

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