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Profile of Mathematical Critical Thinking Abilities of Vocational School Students on Quadratificial Equations Based on Ennis Indicators

Dwi Putri Azisa[1], Syahrir[2], Masjudin[3]
[1,2,3]Program Studi Pendidikan Matematika, FSTT, Universitas Pendidikan Mandalika

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Abstract
Mathematical critical thinking ability is an important skill that students must have in learning mathematics. However, the lack of clear data regarding this ability at SMKN 7 Mataram prompted this study. This study aims to analyze the mathematical critical thinking ability of grade X students of SMKN 7 Mataram on quadratic equations. The study used a qualitative approach with a descriptive type. The research subjects were 460 students from 13 classes. Data were collected through tests, interviews, and documentation, then analyzed using the Miles and Huberman model. The results showed that students' mathematical critical thinking ability was in the medium category, with 102 students (22.22%) in the high category, 230 students (50.00%) in the medium category, and 128 students (27.78%) in the low category. Students in the high category were able to fulfill almost all critical thinking indicators, while students in the medium and low categories still experienced difficulties in providing arguments and evaluating the results of problem solving. The results of this study are expected to be a basis for improving students' mathematical critical thinking ability through more effective learning.

Corresponding Author:
Dwi Putri Azisa
Program Studi Pendidikan Matematika, FSTT, Universitas Pendidikan Mandalika
Email: dwiputriazisa18@gmail.com

1. INTRODUCTION

Education plays a strategic role in developing human resources capable of facing the challenges of the 21st century. One of the competencies focused on in modern learning is critical thinking, namely the ability to analyze information, evaluate arguments, and make logical decisions based on available evidence. In the context of mathematics learning, critical thinking skills are crucial because mathematics requires not only mastery of procedures and calculations but also the ability to understand concepts, reason, and solve problems systematically. Therefore, developing critical mathematical thinking skills needs to be a primary focus in the mathematics learning process in schools (Aprilia, 2021; Muhali, 2019).

Previous research has examined students' mathematical critical thinking skills from various perspectives. Purnaningsih and Zulkarnaen (2022) found that mathematical critical thinking skills are influenced by students' learning style characteristics, resulting in each student group exhibiting a different ability profile. Similar results were also reported by Setiana and Purwoko (2020), who showed variations in mathematical critical thinking skills based on differences in students' internal characteristics. Furthermore, several other studies have focused more on efforts to improve critical thinking skills through the application of specific learning models, such as Problem-Based Learning, collaborative learning, and problem-solving-based approaches. These findings indicate that mathematical critical thinking skills are an important aspect that needs to be developed in mathematics learning.

However, most previous research has focused on factors influencing mathematical critical thinking skills or the effectiveness of a learning model in improving these skills. Research specifically mapping students' mathematical critical thinking skills based on Ennis' critical thinking indicators for quadratic equations is still relatively limited, particularly at the vocational high school (SMK) level. However, mapping skills based on critical thinking indicators can provide more detailed information about students' strengths and weaknesses in each aspect of critical thinking, thus providing a basis for designing more effective learning.

Based on initial observations at SMKN 7 Mataram, it was found that some students still experience difficulties in solving math problems that require analysis, reasoning, and evaluation. Students tend to use formulas directly without understanding the underlying concepts. Furthermore, students' ability to justify their answers and verify their solutions is still suboptimal. This condition indicates the need for a more in-depth study of students' critical mathematical thinking skills, particularly in quadratic equations, a fundamental topic in vocational high school mathematics learning.

The scientific novelty of this study lies in the analysis of the profile of vocational high school students' mathematical critical thinking abilities based on Ennis' critical thinking indicators on quadratic equations. Unlike previous studies that primarily linked critical thinking abilities to specific learning styles or learning models, this study focuses on mapping students' abilities across each of Ennis' critical thinking indicators, resulting in a more comprehensive picture of students' mathematical critical thinking abilities in solving quadratic equation problems.

2. RESEARCH METHODS

This study uses a qualitative approach with a descriptive research type. Descriptive research aims to systematically and in-depth describe students' mathematical critical thinking skills in quadratic equations based on Ennis's critical thinking indicators without providing any specific treatment to the research subjects (Creswell, 2010).

The research subjects were all 460 tenth-grade students of SMKN 7 Mataram from 13 classes. Data collection was conducted through a mathematical critical thinking ability test, semi-structured interviews, and documentation. The test was given to all students to obtain an overview of their level of mathematical critical thinking ability based on predetermined indicators. After the test results were obtained, students were grouped into high, medium, and low categories. Next, three students from each category were selected to be interviewed in depth regarding the thinking processes used in solving quadratic equation problems.

The research procedure began with the development of a mathematical critical thinking ability test instrument based on Ennis's indicators, namely analyzing problems, formulating solution strategies, providing arguments, and evaluating results. The developed instrument was then validated before being used in data collection. The next stage was administering the test to all research subjects, grouping the results based on ability categories, conducting interviews, collecting documentation, and analyzing the data. Data analysis was conducted using the Miles and Huberman model, which includes data reduction, data presentation, and drawing conclusions or verification.

The research flow used can be seen in Figure 1.

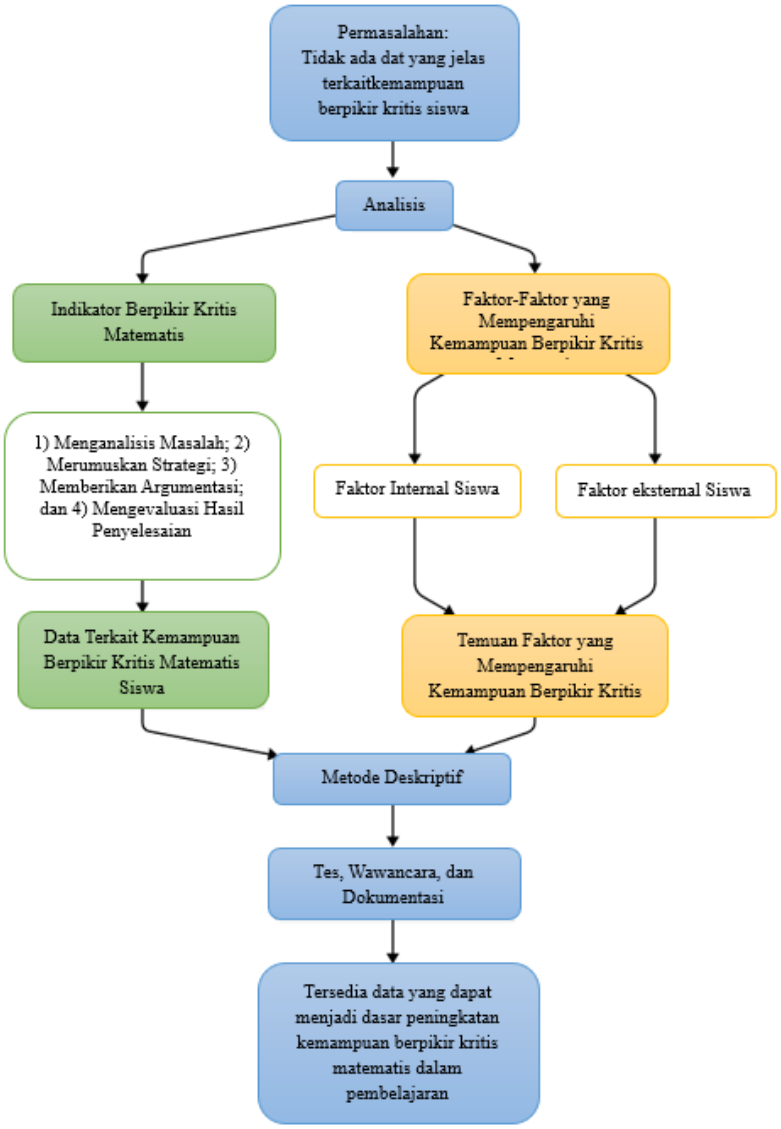

Figure 1. Research Flow

Figure 1 shows the research stages, starting with identifying the problem of students' mathematical critical thinking skills, followed by the development and validation of the research instrument. After the instrument was declared feasible, a test was administered to 460 grade X students of SMKN 7 Mataram. The test results were then used to group students into high, medium, and low categories. Next, nine students were selected as interview subjects to obtain more in-depth data regarding the mathematical critical thinking process. Data from the tests, interviews, and documentation were analyzed using the Miles and Huberman model to obtain conclusions regarding the profile of students' mathematical critical thinking skills in the quadratic equation material.

3. RESULTS AND DISCUSSION

3.1 Research result

This study aims to describe the profile of vocational high school students' mathematical critical thinking skills on quadratic equations based on Ennis' critical thinking indicators. Data were obtained through a mathematical critical thinking ability test administered to 460 grade X students of SMKN 7 Mataram. The test results were then categorized into three categories: high, medium, and low.

Before further analysis is carried out, the distribution of students' mathematical critical thinking abilities is presented in Table 2.

Table 2. Distribution of Students' Mathematical Critical Thinking Abilities

No	Category	Number of Students	Percentage
1	High	102	22,22%
2	Currently	230	50,00%
3	Low	128	27,78%
	Total	460	100%

Based on Table 2, the majority of students are in the medium category, as many as 230 students (50.00%). Students in the high category number 102 students (22.22%), while students in the low category number 128 students (27.78%). These results indicate that the mathematical critical thinking ability of SMKN 7 Mataram students in the quadratic equation material is generally in the medium category.

The distribution of students' mathematical critical thinking abilities based on categories can be seen in Figure 2.

Distribution of Students' Mathematical Critical Thinking Ability

Percentage of students based on the category of mathematical critical thinking ability.

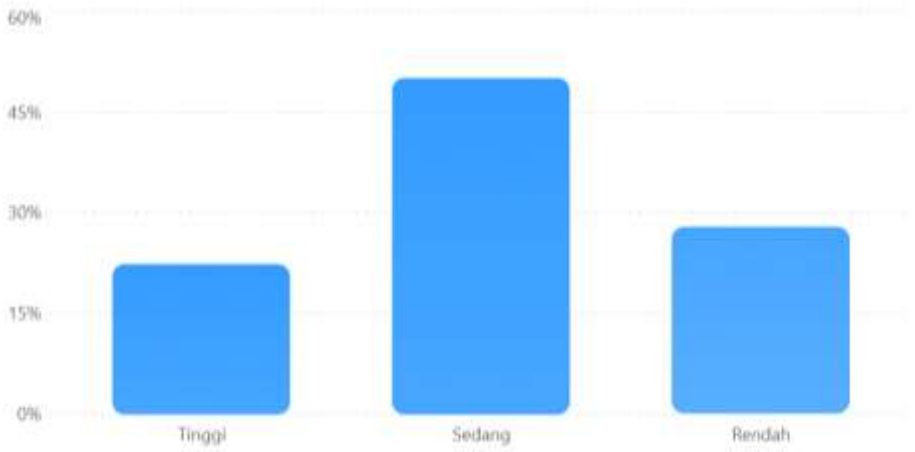

Figure 2. Distribution of Students' Mathematical Critical Thinking Ability

Furthermore, the analysis results based on Ennis's critical thinking indicators show that high-skill students are able to fulfill almost all indicators, namely analyzing problems, formulating solution strategies, providing logical arguments, and evaluating the results of the solution. Medium-skill students are able to understand the problem and determine solution strategies, but still have difficulty in providing complete arguments and evaluating the results obtained. Meanwhile, low-skill students show limitations in identifying known and asked information, difficulty in determining the right solution strategy, and are not yet able to provide reasons and recheck the answers given.

Interview results support these findings. High-achieving students tended to be able to systematically explain the solution steps and provide logical reasons for each procedure. Medium-achieving students were generally able to explain the solution process but lacked confidence in providing mathematical arguments. Meanwhile, low-achieving students tended to focus on using formulas without understanding the underlying concepts.

3.2 Discussion

The results of the study indicate that the critical mathematical thinking skills of students at SMKN 7 Mataram in the quadratic equation topic are in the moderate category. This finding indicates that most students have basic skills in understanding and solving mathematical problems, but have not been able to optimize all critical thinking indicators to their full potential. This condition is evident in the difficulties some students still experience in providing mathematical arguments and evaluating the results of their solutions.

On the problem analysis indicator, most students were able to identify the known and required information in the problem. This ability indicates that students have a fairly good initial understanding of the given problem. However, some students in the lower category still had difficulty connecting the available information to relevant quadratic equation concepts, resulting in inaccurate solution processes.

In the indicator of formulating a solution strategy, students in the high category and most students in the medium category were able to determine appropriate solution methods, such as factoring, completing the square, or using the quadratic formula. Conversely, students in the low category tended to immediately use formulas without considering the strategy's suitability to the characteristics of the problem. This indicates that students' conceptual understanding still needs to be improved to be able to choose more effective strategies.

In the argumentation indicator, students were found to still have difficulty explaining the rationale behind the steps taken to solve problems. Some students were able to obtain the correct answer, but were unable to provide a logical and systematic mathematical explanation. This finding indicates that the learning process still places more emphasis on the final result than on the reasoning process used to obtain the answer.

Meanwhile, regarding the evaluation indicator, most students are not accustomed to double-checking their work. Many students simply accept the answers they receive without verifying the procedures or the final results. Yet, the ability to evaluate is a crucial component of critical thinking because it helps students identify errors and improve the accuracy of problem-solving.

The findings of this study align with previous research, which found that students' critical mathematical thinking skills generally fall within the moderate category and require reinforcement through learning that focuses on problem-solving, discussion, and mathematical reasoning. Teacher-centered learning and the dominance of routine practice problems are among the factors contributing to students' underdevelopment of critical thinking skills.

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Furthermore, the analysis results based on Ennis's critical thinking indicators show that high-skill students are able to fulfill almost all indicators, namely analyzing problems, formulating solution strategies, providing logical arguments, and evaluating the results of the solution. Medium-skill students can understand the problem and determine solution strategies, but still have difficulty in providing complete arguments and evaluating the results obtained. Meanwhile, low-skill students show limitations in

identifying known and asked information, difficulty in determining the right solution strategy, and are not yet able to provide reasons and recheck the answers given.

4. CONCLUSION

This study aims to describe the profile of vocational high school students' mathematical critical thinking skills in quadratic equations based on Ennis' critical thinking indicators. The results indicate that students' mathematical critical thinking skills at SMKN 7 Mataram are generally in the moderate category. This finding indicates that most students have basic skills in understanding and solving mathematical problems, but have not been able to optimize all aspects of critical thinking comprehensively.

The profile of students' mathematical critical thinking skills shows differences in characteristics across each ability category. Students in the high category can analyze problems, formulate solution strategies, provide logical arguments, and evaluate the results effectively. Meanwhile, students in the medium category can understand problems and determine appropriate solution strategies, but still experience difficulties in providing strong mathematical reasoning and double-checking their work. Meanwhile, students in the low category still experience difficulties in identifying important information, determining appropriate solution strategies, providing arguments, and evaluating the answers obtained.

Based on these findings, the aspects of argumentation and evaluation are indicators of critical thinking that require greater attention in mathematics learning. Therefore, teachers need to design learning that provides students with broader opportunities for mathematical analysis, reasoning, discussion, reflection, and proof. This way, students' critical mathematical thinking skills can develop optimally and support the achievement of 21st-century competencies that require higher-order thinking, problem-solving, and rational decision-making.

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