# ANALYSIS OF STUDENTS' MATHEMATICAL CRITICAL THINKING SKILLS IN SOLVING LINEAR EQUATION PROBLEMS BASED ON NCTM INDICATORS

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## Abstract

Mathematical critical thinking skills are essential for analyzing, evaluating, and concluding mathematical problems. This study aimed to describe students' mathematical critical thinking abilities on linear equations using a descriptive qualitative approach. The subjects were 28 eighth-grade students of SMP Negeri 9 Tegal, with nine students selected purposively. Data were collected through tests, interviews, and documentation, and analyzed using the Miles and Huberman model. The results showed that students with high ability met all indicators, while medium- and low-ability students experienced difficulties, particularly in evaluating and concluding.

**Keywords:** mathematical critical thinking; analyzing; evaluating; concluding; linear equations;

## 1. INTRODUCTION

Mathematics plays an important role in developing students' logical reasoning, analytical thinking, and problem-solving skills. In twenty-first-century education, mathematics learning is expected to develop higher-order thinking, particularly mathematical critical thinking, enabling students to analyze information, evaluate arguments, make logical decisions, and solve problems systematically. (Hidayatullah et al., 2019)

The National Council of Teachers of Mathematics (NCTM) emphasizes reasoning, communication, problem solving, connections, and representation in mathematics education. These principles require students to analyze mathematical situations, evaluate solution strategies, and draw logical conclusions based on evidence, which are key components of mathematical critical thinking (NCTM, 2000), (Ikhsan et al., 2017) explained that critical thinking is a cognitive process involving reasoning, judgment, and knowledge construction to achieve a deeper understanding of a problem. Similarly, (Hidayatullah et al., 2019) stated that mathematical critical thinking requires students to identify relevant information, evaluate arguments, and determine the validity of mathematical reasoning. Furthermore, (Mauleto, 2012) contended that critical thinking fosters rational decision-making by prompting students to assess evidence prior to accepting any conclusions. These theoretical viewpoints suggest that mathematical critical thinking goes beyond mere procedural knowledge, requiring students to logically justify their reasoning.

Despite its importance, previous studies have shown that many students still experience difficulties in demonstrating mathematical critical thinking skills. (Oktaviani et al., 2023) reported that students often struggle to express logical arguments during mathematical problem solving, although instructional activities such as questioning and group discussions may improve their thinking processes. Likewise, (Rani & Napitupulu, 2015) found that students with high mathematical critical thinking ability successfully solved problems and drew accurate conclusions, whereas students with medium and low abilities frequently made errors in explanation, calculation, and conclusion formulation. These findings suggest that students' mathematical critical thinking varies considerably according to their ability levels.

Although many studies have examined mathematical critical thinking, few have qualitatively explored students' abilities based on the three NCTM indicators: analyzing, evaluating, and concluding, particularly in solving linear equation problems at the junior high school level. Therefore, further qualitative research is needed to understand students' thinking processes in solving mathematical problems.

Linear equations represent one of the foundational topics in junior high school mathematics, as they serve as a prerequisite for studying coordinate geometry, linear functions, and algebraic reasoning. However, classroom observations and preliminary interviews with mathematics teachers at SMP Negeri 9 Tegal revealed that many students still face difficulties in identifying problem information, choosing appropriate solution strategies, assessing their answers, and formulating logical conclusions when solving linear equation problems. These conditions suggest that students' mathematical critical thinking skills

warrant further investigation in order to identify their strengths and weaknesses across each critical thinking indicator.

This study aims to analyze junior high school students' mathematical critical thinking in solving linear equation problems based on NCTM indicators: analyzing, evaluating, and concluding. The findings are expected to provide insight into students' critical thinking profiles and support teachers in developing strategies that promote higher-order thinking.

## 2. METHODOLOGY

This research adopted a descriptive qualitative design in order to describe students' mathematical critical thinking skills in solving linear equation problems, based on the indicators put forward by the National Council of Teachers of Mathematics (NCTM). A qualitative approach was chosen because it allows for an in-depth exploration of students' thinking processes and yields comprehensive descriptions of their critical thinking abilities within an authentic learning context. (Sugiono, 2023)

This study was conducted at SMP Negeri 9 Tegal, Indonesia, involving 28 eighth-grade students from Class VIII E. Based on a mathematical critical thinking test, students were classified into high, medium, and low ability levels. Nine students, three from each category, were purposively selected as research subjects.

Data were collected through essay tests, semi-structured interviews, and documentation. The test assessed three NCTM indicators: analyzing, evaluating, and concluding. After expert validation and empirical testing, six of seven items met the required criteria and were used in the study. Interviews were conducted to clarify students' answers and explore their reasoning processes.

Data analysis was carried out using the interactive model developed by Miles and Huberman, which comprises three stages: data reduction, data display, and conclusion drawing/verification. In the data reduction stage, students' answers and interview transcripts were organized and categorized according to the three mathematical critical thinking indicators. The reduced data were then presented descriptively through tables and narrative descriptions. Conclusions were subsequently drawn by comparing the results of the written tests and interviews to identify students' mathematical critical thinking profiles across the different ability levels. The credibility of the findings was further reinforced through method triangulation, in which the consistency between students' written responses and their interview results was examined.

## 3. RESULTS

This study sought to describe students' mathematical critical thinking skills in solving linear equation problems based on three NCTM indicators: analyzing, evaluating, and drawing conclusions from arguments. The findings were derived from essay tests and semi-structured interviews conducted with nine selected students representing high, medium, and low levels of mathematical critical thinking ability. The analysis centered on students' performance in relation to each indicator.

### 3.1 Students' Mathematical Critical Thinking Ability

Based on the results of the mathematical critical thinking test, students were classified into three ability levels: high, medium, and low. Three students from each category were selected for further analysis through interviews. The categorization enabled the researcher to examine differences in students' critical thinking characteristics across ability levels

**Table 1.** Research Subjects

| Ability Level | Code | Number of Students |
|---|---|---|
| **High** | **ST-1, ST-2, ST-3** | **3** |
| **Medium** | **SS-1, SS-2, SS-3** | **3** |
| **Low** | **SR-1, SR-2, SR-3** | **3** |

### 3.2 Analysis Indicator

Students in the high-ability group were able to accurately identify the given and required information stated in the problem. They correctly interpreted the mathematical information provided and devised appropriate strategies prior to solving the problems. Their written answers were systematically structured and were reinforced by clear explanations given during the interviews.

Students in the medium-ability group were generally capable of recognizing the key information within the problems, although they occasionally overlooked relevant details or misinterpreted certain

mathematical relationships. While they showed an understanding of the problem context, some inaccuracies persisted in their initial analysis.

Students in the low-ability group, by contrast, faced significant difficulty in identifying relevant information. Several were unable to differentiate between known and unknown variables, which led to inappropriate solution strategies from the very outset of the problem-solving process. These findings suggest that analytical ability varied considerably across the three ability levels.

### 3.3 Evaluation Indicator

Students with high mathematical critical thinking ability evaluated each step of their solutions in a careful and consistent manner. They checked their calculations, provided justification for the mathematical procedures used, and were able to correct minor errors on their own. The interview results confirmed that these students deliberately reviewed their work before arriving at conclusions.

Students in the medium-ability group completed most of the solution steps correctly but rarely went back to re-evaluate their calculations. As a result, computational errors and incomplete reasoning occasionally persisted in their final answers.

Students in the low-ability group, meanwhile, exhibited considerable difficulty in evaluating their own solutions. Most of them accepted their initial answers without verification and were unable to explain why a given procedure was appropriate. This weakness contributed to the overall inaccuracy of their solutions.

### 3.4 Concluding Indicator

The high-ability group successfully formulated logical conclusions that were consistent with the context of the problem and supported by sound mathematical reasoning. Their conclusions accurately summarized the results obtained and reflected a thorough understanding of the problem.

Students in the medium-ability group generally provided conclusions, but these were often incomplete or insufficiently justified. Some participants simply restated their numerical answers without linking them back to the mathematical context

Students in the low-ability group faced the greatest challenges in formulating conclusions. Several students failed to provide any conclusion at all, while others produced statements unrelated to the solutions they had obtained. The interview findings revealed that these students were uncertain about how to formulate mathematical conclusions after completing their calculations.

### 3.5 Summary of Findings

The overall findings point to clear differences in mathematical critical thinking skills among students at different ability levels. Students in the high category successfully met all three NCTM indicators. Those in the medium category displayed satisfactory analytical skills but faced difficulties in evaluating solution processes and formulating complete conclusions. Students in the low category, meanwhile, encountered difficulties across all three indicators, particularly in evaluating mathematical procedures and drawing logical conclusions. These results offer an overview of students' mathematical critical thinking profiles in solving linear equation problems and form the basis for further discussion regarding the factors underlying these differences.

## 4. Conclusions

This study examined junior high school students' mathematical critical thinking skills in solving linear equation problems, based on the indicators established by the National Council of Teachers of Mathematics (NCTM), namely analyzing, evaluating, and drawing conclusions from arguments. The findings demonstrated clear differences in mathematical critical thinking skills among students at different ability levels.

Students in the high-ability category successfully exhibited all three indicators of mathematical critical thinking. They were capable of identifying relevant information, evaluating solution procedures accurately, and formulating logical conclusions supported by sound mathematical reasoning. Students in the medium-ability category generally performed satisfactorily in analyzing mathematical problems; however, they faced difficulties in evaluating their solution strategies and constructing complete conclusions. Students in the low-ability category, on the other hand, encountered difficulties across all three indicators, particularly in evaluating mathematical procedures and drawing valid conclusions, which led to incomplete and less accurate problem-solving processes.

Overall, the results suggest that evaluating and concluding are the most challenging aspects of mathematical critical thinking in solving linear equation problems. These findings offer valuable insight into students' critical thinking profiles and may serve as a reference for mathematics educators in designing learning activities that encourage students to develop higher-order thinking skills through problem-solving, mathematical reasoning, and reflective learning.

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