



Original Research

Students' Mathematical Critical Thinking Skills on Systems of Linear Equations in Two Variables: A Gender-Based Analysis

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Abstract

This study aims to describe the mathematical critical thinking skills of male and female students in the topic of Systems of Linear Equations in Two Variables (SLETV) and to examine whether there is a significant difference in mathematical critical thinking skills between the two groups. The study employed a descriptive method using quantitative and qualitative approaches. The participants consisted of 30 eighth-grade students at MTs Negeri 2 Bolaang Mongondow Selatan, including 15 male and 15 female students. Data were collected through a mathematical critical thinking test and interviews. Mathematical critical thinking skills were analyzed based on four indicators: interpretation, analysis, evaluation, and inference. The findings indicate that female students achieved higher average mathematical critical thinking scores than male students across all indicators, particularly in interpretation and inference. Interview results also revealed that female students tended to be more careful in interpreting information and drawing conclusions. However, the independent samples *t*-test showed that the difference in mathematical critical thinking skills between the two groups was not statistically significant at the 5% significance level.

Keywords: Mathematical Critical Thinking Skills; Gender; Systems of Linear Equations in Two Variables; Mathematics Education

1. Introduction

Mathematics is one of the fundamental subjects that plays an important role in developing students' logical, systematic, analytical, and creative thinking skills. Mathematics learning is not only intended to enable students to master mathematical concepts but also to equip them with the ability to analyze problems and determine appropriate solutions [1, 2].

One of the essential objectives of mathematics education is the development of mathematical critical thinking skills. These skills enable students to identify relevant information, analyze relationships among concepts, evaluate problem-solving strategies, and draw logical conclusions when dealing with mathematical problems [3, 4]. Mathematical critical thinking is also recognized as one of the key competencies required for 21st-century learning, as it helps students make decisions based on rational reasoning and available evidence [4].

Numerous studies have shown that students' mathematical critical thinking skills still need improvement. Susanti *et al.* [5] reported that the critical thinking skills of students who learned using interactive multimedia remained at a moderate level, indicating the need for learning approaches that optimally develop each indicator of critical thinking. Similarly, Niode *et al.* [6] found that the implementation of the Self-Organized Learning Environment (SOLE) model gradually improved students' mathematical critical thinking skills through student-centered learning. In addition to critical thinking, analytical thinking and problem-solving skills are closely related competencies in mathematics education. Napui *et al.* [7] found that students' analytical thinking skills in fraction operations were still categorized as moderate. Meanwhile, Patingki *et al.* [8] demonstrated that cognitive style has a strong relationship with students' mathematical problem-solving abilities. These findings indicate that students' higher-order thinking skills are influenced by various factors and therefore require greater attention in the learning process.

One of the mathematics topics that requires strong mathematical critical thinking skills is the System of Linear Equations in Two Variables (SLETV). In this topic, students are expected to understand the given information, formulate mathematical models, select appropriate solution strategies, and interpret the obtained solutions according to the context of the problem [9]. In addition to instructional factors, individual characteristics, including gender, are also believed to influence mathematical critical thinking skills. Hidayanti *et al.* [10] reported that female students tend to be more careful in organizing solution steps, whereas Rosmayadi *et al.* [11] found that differences in mathematical critical thinking skills between male and female students are not necessarily statistically significant across different learning contexts. These inconsistent findings suggest that the relationship between gender and mathematical critical thinking remains an important topic for further investigation across different educational levels and mathematical topics.

Based on interviews with a mathematics teacher at MTs Negeri 2 Bolaang Mongondow Selatan, it was found that students' ability to solve SLETV problems varied considerably. While some students were able to solve the problems successfully, many still experienced difficulties in identifying relevant information, constructing mathematical models, and drawing appropriate conclusions. Therefore, this study aims to describe the mathematical critical thinking skills of male and female students in the topic of the System of Linear Equations in Two Variables (SLETV) and to analyze whether there is a significant difference in mathematical critical thinking skills between the two groups.

2. Methods

This study was conducted at MTs Negeri 2 Bolaang Mongondow Selatan during the first semester of the 2023/2024 academic year. A descriptive research design with quantitative and qualitative approaches was employed. The quantitative approach was used to describe students' mathematical critical thinking skills based on test results and to examine differences in mathematical critical thinking skills between male and female students. Meanwhile, the qualitative approach was used to obtain a deeper understanding of students' thinking processes through interviews.

The participants consisted of 30 eighth-grade students from MTs Negeri 2 Bolaang Mongondow Selatan, including 15 male and 15 female students. The participants were selected using a purposive sampling technique based on the consideration that all participants had studied the topic of the System of Linear Equations in Two Variables (SLETV).

The research instruments consisted of a mathematical critical thinking test and an interview guide. The test comprised essay questions developed based on four indicators of mathematical critical thinking: interpretation, analysis, evaluation, and inference. Prior to data collection, the test instrument was examined for validity and reliability to ensure its suitability for measuring students' mathematical critical thinking skills.

The test data were analyzed descriptively using the mean score and the percentage of achievement for each indicator of mathematical critical thinking. Furthermore, students' mathematical critical thinking skills were classified into three categories (high, moderate, and low) based on the mean ($\bar{x}$) and standard deviation (SD). The classification criteria are presented in Table 1.

Based on the test results, the mean score of students' mathematical critical thinking skills was 29.27 with a standard deviation of 9.927. Based on these values, the classification of students' mathematical critical thinking skills is presented in Table 2.

Table 1: Classification Criteria for Mathematical Critical Thinking Skills

Category	Criterion
High	$x \geq \bar{x} + SD$
Moderate	$\bar{x} - SD \leq x < \bar{x} + SD$
Low	$x < \bar{x} - SD$

Table 2: Categories of Students' Mathematical Critical Thinking Skills

Category	Score Interval
High	$x \geq 39.20$
Moderate	$19.34 \leq x < 39.20$
Low	$x < 19.34$

The interview data were analyzed descriptively through the stages of data reduction, data presentation, and conclusion drawing. The interview findings were used to strengthen the interpretation of the mathematical critical thinking test results.

To determine whether there was a significant difference in mathematical critical thinking skills between male and female students, an independent samples *t*-test was conducted at a significance level of 5%. The hypotheses tested were as follows:

H_0 : There is no significant difference in mathematical critical thinking skills between male and female students.

H_1 : There is a significant difference in mathematical critical thinking skills between male and female students.

The test statistic is given by

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}, \quad (1)$$

where $\bar{x}_1$ denotes the mean mathematical critical thinking score of female students, $\bar{x}_2$ denotes the mean mathematical critical thinking score of male students, s_1^2 and s_2^2 represent the variances of female and male students, respectively, and n_1 and n_2 denote the numbers of female and male students.

The decision was made by comparing the calculated *t*-value with the critical *t*-value at the 5% significance level. The null hypothesis (H_0) was accepted if $t_{\text{calculated}} < t_{\text{critical}}$; otherwise, H_0 was rejected.

3. Results and Discussion

3.1 Description of the Research Data

3.1.1 Test Results

A written test was administered to all research participants to describe students' mathematical critical thinking skills based on gender in the topic of Systems of Linear Equations in Two Variables (SLETV). Mathematical critical thinking skills were analyzed based on four indicators, namely interpretation, analysis, evaluation, and inference. The average achievement percentage for each indicator is presented in Table 3.

Table 3: Students' Mathematical Critical Thinking Skills by Indicator

Indicator	Male Students (%)	Female Students (%)
Interpretation	51	74
Analysis	70	80
Evaluation	63	75
Inference	38	54
Average	56	70

Based on Table 3, female students achieved higher average mathematical critical thinking scores than male students across all measured indicators. The largest differences were observed in the interpretation and inference

indicators, whereas the differences in the analysis and evaluation indicators were relatively smaller. Overall, female students achieved an average score of 70%, while male students obtained an average score of 56%. A comparison of the achievement percentages for each indicator is presented in Figure 1.

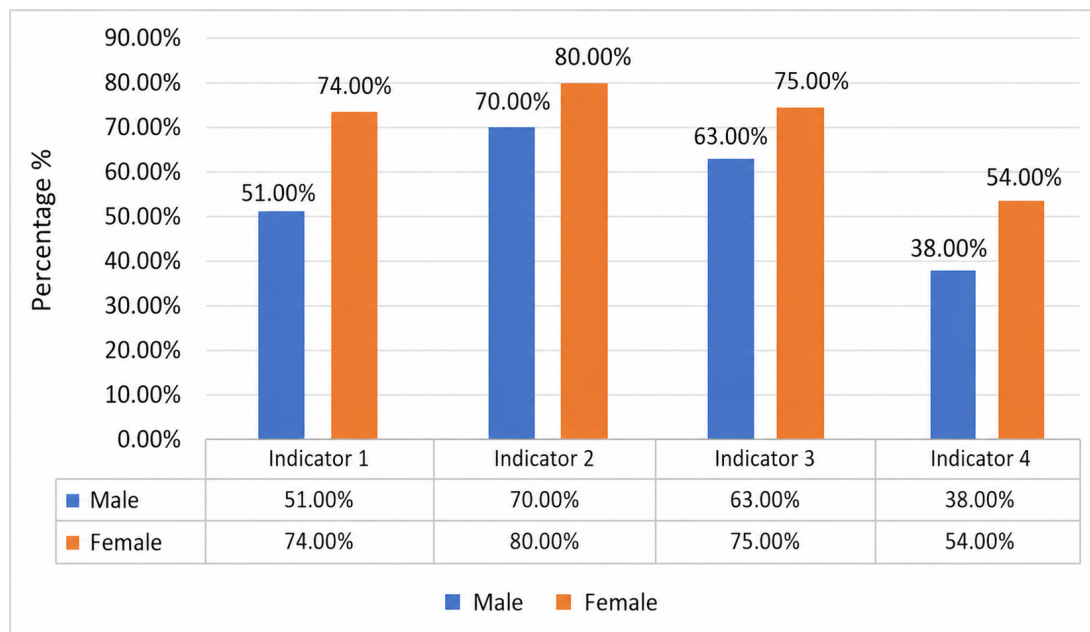


Figure 1: Percentage of Mathematical Critical Thinking Skills by Indicator

Based on Figure 1, female students consistently outperformed male students across all indicators of mathematical critical thinking. These findings indicate that female students tended to demonstrate better abilities in understanding information, analyzing problems, evaluating solution strategies, and drawing conclusions when solving SLETV problems.

Interpretation Indicator The interpretation indicator measures students' ability to identify and restate the information provided and the questions posed in a problem. Based on the test results, female students achieved an average score of 74%, whereas male students achieved 51%. These findings indicate that female students tended to be more careful in identifying important information and were therefore able to write the known and required information more completely. In contrast, some male students overlooked information they considered less important, resulting in incomplete problem representations.

Analysis Indicator The analysis indicator measures students' ability to identify relationships among the given information and construct an appropriate mathematical model. Female students obtained an average score of 80%, while male students achieved 70%. Although the difference was relatively small, female students demonstrated better performance in connecting available information and systematically formulating mathematical models. Male students generally succeeded in constructing appropriate mathematical models; however, several errors were observed in identifying the relationships among variables.

Evaluation Indicator The evaluation indicator assesses students' ability to select appropriate solution strategies and execute the solution procedures correctly. Female students obtained an average score of 75%, whereas male students achieved 63%. These results indicate that both groups were generally able to select appropriate solution strategies. However, female students tended to explain each solution step more systematically, whereas male students focused primarily on obtaining the final answer. Computational errors affecting the final results were still observed in both groups.

Inference Indicator The inference indicator measures students' ability to draw conclusions based on the obtained solutions. Female students achieved an average score of 54%, while male students obtained 38%. This indicator produced the lowest scores for both groups, indicating that many students were not accustomed to

writing conclusions as the final step of the problem-solving process. Nevertheless, female students were more consistent in drawing conclusions that were consistent with their solutions than male students.

3.1.2 Interview Results

Interviews were conducted with six students consisting of three male and three female students. The participants were selected based on three levels of mathematical critical thinking ability, namely high, moderate, and low. The interviews aimed to obtain a deeper understanding of students' thinking processes in solving SLETV problems based on the four indicators of mathematical critical thinking.

Interpretation Students with high mathematical critical thinking skills were able to identify the known and required information and express it in the form of appropriate mathematical models. In contrast, students with moderate and low abilities experienced difficulties in identifying all relevant information contained in the problems. Female students also tended to provide more complete descriptions of the given information than male students.

Analysis Students with high mathematical critical thinking skills successfully connected the available information and formulated appropriate mathematical models. Students with moderate ability still made errors in determining variables or constructing mathematical models. Meanwhile, students with low ability experienced difficulties in relating the available information, resulting in inappropriate mathematical models.

Evaluation Students with high mathematical critical thinking skills were able to select appropriate solution strategies, such as the elimination or substitution methods, and recheck their solutions. In contrast, students with moderate and low abilities experienced difficulties in selecting suitable solution strategies and frequently made computational errors during the solution process.

Inference For the inference indicator, female students were more consistent in writing conclusions that were aligned with their solutions. Conversely, several male students either omitted the conclusion entirely or provided conclusions that were inconsistent with their obtained solutions.

3.1.3 Independent Samples *t*-Test Results

An independent samples *t*-test was conducted to determine whether there was a significant difference in mathematical critical thinking skills between male and female students in the topic of Systems of Linear Equations in Two Variables (SLETV). The tested hypotheses were as follows:

H_0 : There is no significant difference in mathematical critical thinking skills between male and female students.

H_1 : There is a significant difference in mathematical critical thinking skills between male and female students.

The results of the independent samples *t*-test showed that the calculated *t*-value was smaller than the critical *t*-value at the 5% significance level with 28 degrees of freedom. Therefore, H_0 was accepted and H_1 was rejected. These findings indicate that there was no statistically significant difference in mathematical critical thinking skills between male and female students, although female students obtained higher average scores across all critical thinking indicators.

3.2 Discussion

3.2.1 Mathematical Critical Thinking Skills of Male Students

The findings indicate that male students achieved their highest performance on the analysis indicator (70%), followed by the evaluation indicator (63%). These results suggest that most male students were able to identify relationships among the information provided, formulate mathematical models, and determine appropriate solution strategies. The interview results further revealed that male students tended to adopt a direct problem-solving approach without providing extensive explanations of the given information.

Nevertheless, male students demonstrated relatively lower performance on the interpretation and inference indicators. In particular, the inference indicator achieved only 38%, indicating that many students were not

accustomed to drawing conclusions based on their solutions. Several students focused mainly on obtaining the final answer while neglecting the conclusion stage. Therefore, mathematics instruction should emphasize not only obtaining correct answers but also communicating solution processes and formulating logical conclusions systematically.

3.2.2 Mathematical Critical Thinking Skills of Female Students

Female students achieved higher average mathematical critical thinking scores than male students across all indicators. The highest achievement was obtained in the analysis indicator (80%), followed by evaluation (75%) and interpretation (74%). These findings indicate that female students demonstrated strong abilities in identifying information, constructing mathematical models, selecting appropriate solution strategies, and systematically explaining the solution process.

For the inference indicator, female students also outperformed male students, although this indicator remained the lowest-scoring aspect for both groups. The interview findings revealed that female students were more consistent in writing conclusions that corresponded to their solutions. This suggests that female students paid greater attention to the completeness of the problem-solving process, from identifying information to drawing conclusions.

These findings are consistent with those reported by Hidayanti *et al.* [10], who found that female students tend to be more careful in understanding problems, organizing solution procedures, and presenting complete answers. Such carefulness contributes to their relatively higher mathematical critical thinking performance across most indicators.

3.2.3 Comparison of Mathematical Critical Thinking Skills Between Male and Female Students

Based on the descriptive analysis, female students achieved higher average mathematical critical thinking scores than male students across all indicators, including interpretation, analysis, evaluation, and inference. However, the inferential analysis indicated that these differences were not statistically significant.

The independent samples *t*-test yielded a calculated *t*-value of 1.79, whereas the critical *t*-value at the 5% significance level with 28 degrees of freedom was 2.048. Since the calculated *t*-value was smaller than the critical value ($1.79 < 2.048$), H_0 was accepted and H_1 was rejected. Therefore, no statistically significant difference was found in mathematical critical thinking skills between male and female students in the topic of Systems of Linear Equations in Two Variables (SLETV).

Table 4: Results of the Independent Samples *t*-Test

Group	<i>n</i>	Mean	Variance	<i>t</i> -value	<i>t</i> -critical
Male	15	55.50%	119.81	1.79	2.048
Female	15	64.75%	89.84		

Although female students achieved higher average mathematical critical thinking scores than male students, the observed difference was insufficient to demonstrate statistical significance. This finding suggests that mathematical critical thinking skills are not determined solely by gender but may also be influenced by factors such as prior knowledge, learning experiences, motivation, instructional strategies, and the learning environment. Therefore, efforts to improve mathematical critical thinking should focus on providing learning experiences that encourage students to interpret problems, analyze information, evaluate solution processes, and draw logical conclusions systematically, regardless of gender.

4. Conclusion

Based on the findings of this study, it can be concluded that female students demonstrated higher mathematical critical thinking skills than male students in the topic of Systems of Linear Equations in Two Variables (SLETV) from a descriptive perspective. Female students achieved higher percentages across all critical thinking indicators, namely interpretation, analysis, evaluation, and inference. Meanwhile, male students showed relatively good performance in the analysis and evaluation indicators but experienced greater difficulties in interpretation and especially inference.

The interview findings indicated that female students tended to be more careful in identifying information, constructing mathematical models, explaining solution procedures, and drawing conclusions. In contrast, several male students focused primarily on obtaining the final answer and therefore provided less complete solution processes and conclusions. However, the independent samples t -test demonstrated that there was no statistically significant difference in mathematical critical thinking skills between male and female students at the 5% significance level. Therefore, although descriptive differences were observed, these differences were not statistically significant.

The findings of this study are expected to provide useful insights for mathematics teachers in designing instructional activities that foster students' mathematical critical thinking skills across all indicators, particularly interpretation and inference, without differentiating instruction based on gender.

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Conflicts of Interest

The authors declare no conflict of interest.

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