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ANALYSIS OF STUDENTS' MATHEMATICAL CRITICAL THINKING SKILLS – A CASE ON TWO VARIABLES LINEAR EQUATION SYSTEM

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ABSTRACT

Critical thinking is an essential component of mathematics learning, particularly when students are required to solve word problems that demand reasoning, interpretation, and systematic decision-making. However, evidence from previous studies shows that many junior high school students still struggle to apply critical thinking skills effectively, especially in the topic of Systems of Linear Equations in Two Variables (SPLDV). This study aims to analyze the types of errors made by students when solving SPLDV word problems based on indicators of mathematical critical thinking skills. This qualitative descriptive study involved 36 eighth-grade students from SMP Negeri 1 Ciranjang. The data were collected through five open-ended test items developed according to four indicators of mathematical critical thinking: interpretation, analysis, evaluation, and inference. Students' written responses were scored using an established rubric, and the data were analyzed through the processes of data reduction, data presentation, and conclusion drawing. The findings show that students frequently experienced several types of difficulties, including: (1) failing to identify the known and asked information; (2) using unsystematic problem-solving procedures; (3) constructing incorrect or incomplete mathematical models; (4) applying inappropriate strategies; (5) performing inaccurate or incomplete calculations; and (6) being unable to draw conclusions aligned with the context of the problem. These results indicate that students' mathematical critical thinking skills related to SPLDV remain weak and require improvement. Therefore, structured guidance, explicit reasoning instruction, and consistent practice are needed to strengthen students' problem solving abilities.

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INTRODUCTION

Critical thinking plays a crucial role in mathematics education because it helps students interpret information, apply logical reasoning, make informed decisions, and solve problems

more effectively. Mathematics instruction is designed to develop students' abilities to think logically, analytically, systematically, critically, and creatively (Rahmaniah et al., 2023), making critical thinking an essential component of their cognitive growth. These skills are particularly important in helping students navigate a rapidly changing and increasingly competitive environment (Wulandari et al., 2023). In the context of 21st century learning, critical thinking is also recognized as one of the core competencies that must be developed through mathematics because it supports students' ability to reason, evaluate evidence, and construct coherent mathematical arguments (Hidayat & Irawan, 2020; NCTM, 2014).

Despite its recognized importance, many students both globally and in Indonesia still demonstrate low levels of mathematical critical thinking. Results from the Trends in International Mathematics and Science Study (TIMSS) show that Indonesian students often experience difficulties when working on items that require higher order reasoning and critical thinking (Syafitri et al., 2021). International assessments such as PISA have also consistently reported that Indonesian students struggle with interpreting information, modeling contextual problems, and applying logical reasoning (OECD, 2019). National research further indicates that junior high school students frequently struggle to interpret problem information, analyze relationships, formulate logical arguments, and draw appropriate conclusions (Rosliani & Munandar, 2022; Putri & Hasanah, 2021; Widodo & Purnomo, 2020). These findings highlight a persistent gap between expected competencies and students' actual performance.

Such challenges are also noticeable in specific mathematical content areas, particularly in Systems of Linear Equations in Two Variables (SPLDV). Mastery of SPLDV involves understanding contextual word problems, identifying known and unknown components, building accurate mathematical models, and applying systematic procedures to find solutions. However, many students continue to face obstacles, including misinterpreting problem statements, forming incorrect equations, using ineffective problem-solving strategies, and neglecting to check their final solutions (Baweleng et al., 2023; Nurhasanah & Anriani, 2020; Sari & Wijaya, 2021). These recurring difficulties indicate that students' reasoning, modeling, and analytical skills are still underdeveloped within this material.

In response to these issues, this study seeks to examine the types of errors made by eighth-grade students when working on SPLDV word problems, using mathematical critical thinking indicators as the basis of analysis. The findings are intended to provide a deeper understanding of students' challenges and contribute to efforts to improve critical thinking within mathematics instruction. Strengthening students' ability to think critically in SPLDV is expected not only to support their achievement in algebra but also to enhance their readiness for advanced mathematical concepts and real-life problem solving.

METHOD

This study employed a qualitative descriptive method to investigate students' errors in solving word problems on Systems of Linear Equations in Two Variables (SPLDV) based on indicators of mathematical critical thinking skills. The participants were 36 eighth grade students from class VIII.F at SMP Negeri 1 Ciranjang. The research instrument consisted of five open ended items developed to measure four indicators of mathematical critical thinking interpretation, analysis, evaluation, and inference. The research procedures included designing the instrument and scoring rubric, administering the test in a supervised classroom setting, collecting and coding students' written responses, scoring each answer using a 0–4 analytic rubric, and organizing the data into descriptive categories. Data were analyzed through descriptive quantitative scoring and qualitative thematic analysis by reducing the data, identifying and coding recurring error patterns, grouping them into themes, presenting frequencies and

descriptive narratives, and drawing conclusions about students' mathematical critical thinking skills for each indicator.

RESULTS AND DISCUSSION

Results

The results of the analysis of students' responses to the SPLDV word problem test were categorized into five types of answers: (1) answering correctly in a systematic manner, (2) answering correctly through trial and error, (3) answering incompletely, (4) answering incorrectly, and (5) not providing an answer. The distribution of students' responses to each question is presented in Table 1.

Table 1. Students' Responses Distribution

No	Answer Criteria	Percentage (%)				
		Question 1	Question 2	Question 3	Question 4	Question 5
1	Answering correctly in a systematic manner	0 %	0 %	0 %	0 %	0 %
2	Answering correctly through trial and error	42 %	31 %	39 %	42 %	42 %
3	Answering incompletely	31 %	28 %	19 %	25 %	31 %
4	Answering incorrectly	25 %	33 %	36 %	19 %	25 %
5	Not providing an answer	3 %	8 %	6 %	14 %	3 %

Overall, the table shows that none of the students answered systematically correct, indicating that students have not yet applied the complete sequence of critical thinking processes. The highest proportion of responses falls into the trial and error category, suggesting that many students tend to guess or rely on informal reasoning instead of structured mathematical procedures. Incomplete answers and incorrect answers also appear frequently across questions, showing difficulties in understanding information, constructing mathematical models, and performing solution steps. The analysis focuses on four indicators of mathematical critical thinking interpretation, analysis, evaluation, and inference by examining representative student answers presented in Figures 1–4.

1. Answering Correctly in a Systematic Manner

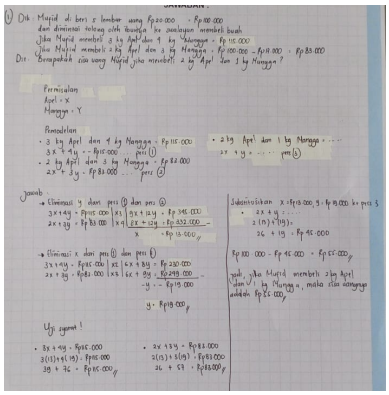

Figure 1. Answering correctly in a systematic manner

Figure 1 shows a student response demonstrating strong performance across all critical thinking indicators. The student accurately identified the known and asked information (interpretation), constructed correct mathematical models (analysis), selected appropriate procedures such as substitution or elimination and performed the calculations accurately (evaluation), and formulated a complete and contextually correct conclusion (inference). Although no student achieved this level on all test items, this example illustrates how a fully developed mathematical critical thinking process should appear.

2. Answering Correctly Through Trial and Error

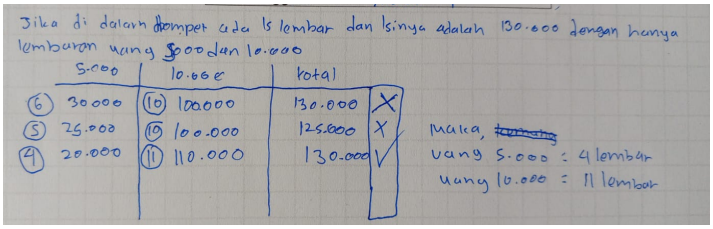

Figure 2. Answering correctly through trial and error

Figure 2 indicates that some students obtained the correct answer but relied primarily on trial-and-error methods rather than formal SPLDV procedures. Their interpretation and analysis skills were adequate, as they correctly identified information and constructed equations. However, their evaluation skills were weak because they avoided systematic algebraic methods, reducing the transferability of their problem-solving strategies. Their conclusions were also incomplete, demonstrating minimal inference skills. This suggests that correct answers do not necessarily reflect strong critical thinking.

3. Answering Incompletely

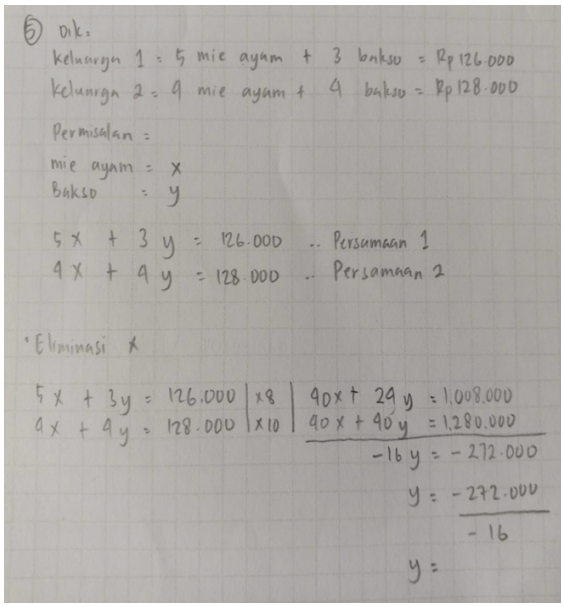

Figure 3. Answering incompletely

Figure 3 shows a response where the student demonstrated partial mastery of the interpretation and analysis indicators but did not complete the solution. Although the student successfully identified known and asked information and constructed an initial mathematical model, they were unable to continue the strategy to completion (evaluation) and did not formulate a conclusion (inference). This pattern indicates that many students understand SPLDV concepts at a surface level but struggle to execute multi step procedures.

4. Answering Incorrectly

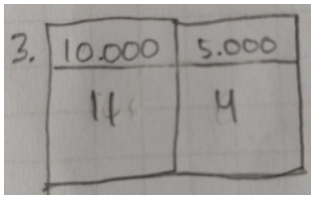

Figure 4. Answering incorrectly

Figure 4 illustrates responses from students who were unable to meet most of the critical thinking indicators. These students did not identify essential problem information (interpretation), failed to construct mathematical models (analysis), applied incorrect or unsystematic strategies (evaluation), and did not reach logical conclusions (inference). Such errors suggest weaknesses in foundational conceptual understanding, resulting in difficulty applying reasoning procedures required in SPLDV word problems.

Discussions

The findings of this study align with results reported in several previous studies. Rosliani and Munandar (2022) similarly found that many students struggle to identify essential information and draw logical conclusions, consistent with the weak interpretation and inference indicators observed here. Likewise, Baweleng et al. (2023) noted that students often misinterpret word problems and construct inaccurate equations, reinforcing this study's findings regarding weaknesses in the analysis indicator. Putri and Hasanah (2021) reported that junior high school students frequently rely on unsystematic trial and error methods in algebraic tasks, reflecting the low evaluation performance found in this research. Hidayat and Irawan (2020) also observed that students rarely justify their answers, which corresponds with the limited inference abilities demonstrated by students in this study. Furthermore, Widodo and Purnomo (2020) highlighted persistent challenges in modeling and reasoning within algebraic contexts, supporting this study's conclusion that constructing and applying mathematical models in SPLDV remains difficult for many students.

Collectively, these comparisons strengthen the conclusion that students' mathematical critical thinking skills are still weak across multiple indicators particularly analysis, evaluation, and inference and highlight the need for more targeted instructional practices to enhance reasoning, modeling, and decision-making in contextual mathematical tasks.

CONCLUSION

Based on the results of the analysis and discussion, it can be concluded that students' mathematical critical thinking skills in solving SPLDV word problems are still generally low across all four indicators. In terms of interpretation, many students were unable to clearly identify what information was known and what was being asked, often overlooking key elements of the problem. For the analysis indicator, a large number of students had difficulty constructing accurate mathematical models, and many produced incomplete or incorrect equations, indicating weak conceptual understanding of SPLDV. With regard to evaluation, students frequently relied on unsystematic trial-and-error strategies, made computational errors, and were unable to apply formal SPLDV procedures such as elimination or substitution correctly. Finally, for the inference indicator, most students were unable to formulate conclusions that aligned with the context of the problem, with many responses lacking justification or providing irrelevant final statements.

Overall, these findings demonstrate that students have not yet developed strong reasoning, modeling, and problem-solving skills needed to solve SPLDV word problems effectively.

Therefore, it is recommended that students receive more structured guidance and regular practice in identifying known and unknown information, constructing mathematical models, selecting appropriate solution strategies, and formulating clear conclusions. Strengthening these four indicators of mathematical critical thinking is expected to improve students' ability to solve SPLDV problems systematically and accurately.

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