Vol. 15, No. 02, pp. 1142-1156, 2025 DOI: 10.23960/jpp.v15i2.pp1142-1156

Jurnal Pendidikan Progresif

e-ISSN: 2550-1313 | p-ISSN: 2087-9849

http://jurnal.fkip.unila.ac.id/index.php/jpp/

Analyzing the Mathematical Critical Thinking Skills of High School Students in Arithmetic: A Gender Differences

Putri Ardhanita Harahap*, Rivani Adistia Dewi, & Tia Purniati

Department of Mathematics Education, Universitas Pendidikan Indonesia, Indonesia

*Corresponding email: putriardhanita@gmal.com

Received: 03 May 2025 *Accepted: 29 May 2025* *Published: 01 June 2025*

Abstract: Analyzing the Mathematical Critical Thinking Skills of High School Students in Arithmetic: A Gender Differences. Objective: The purpose of this investigation is to evaluate the mathematical critical thinking abilities of senior high school pupils in the field of arithmetic in relation to gender. In particular, it examines the critical thinking patterns of male and female pupils at varying ability levels (high, medium, and low) using four primary indicators: interpretation, analysis, evaluation, and inference. **Methods**: A qualitative descriptive methodology was implemented. A purposive selection of six tenth-grade students was made from a pool of 31 participants based on the results of an initial critical thinking test. These six pupils represented all three ability categories and both genders. Critical thinking essay assessments, semi-structured interviews, and classroom observations were implemented to accumulate data. The data was analyzed using source triangulation, reduction, and categorization in accordance with Facione's indicators. **Findings**: The findings indicated that female students exhibited more systematic and circumspect approaches, which led to their success in interpretation and analysis. In contrast, male pupils were more responsive but less meticulous and reflective. In terms of evaluation, the majority of students in all categories did not assess their work, which suggests that they have inadequate metacognitive abilities. Despite the fact that their final answers were accurate, numerous students were unable to articulate explicit conclusions regarding inference. High-ability students exhibited strategic planning and reflective thinking, whereas low-ability students relied on procedural and rote-based methods. **Conclusion**: The study emphasizes the significance of instructional strategies that are responsive to ability and gender. Integrating mathematical communication, reflection, and explicit training in evaluation and inference are critical components of effective teaching strategies that promote the development of critical thinking. According to the results, female students are more structured and reflective, whereas male students are more evaluative but less quickly. The necessity of instructional designs that are consistent with the unique characteristics of students is suggested by the fact that these differences are influenced by cognitive styles, confidence levels, and learning patterns.

Keywords: mathematical critical thinking skills, high school students, gender.

To cite this article:

Harahap, P. A., Dewi, R. A., & Purniati, T. (2025). Analyzing the Mathematical Critical Thinking Skills of High School Students in Arithmetic: A Gender Differences. *Jurnal Pendidikan Progresif*, *15*(2), 1142-1156. doi: 10.23960/jpp.v15i2.pp1142-1156.

INTRODUCTION

It is crucial for students to possess critical thinking as one of the primary competencies of the 21st century in order to effectively address the challenges of a complex, ambiguous, and dynamic world. Critical thinking, in the context of mathematics education, is instrumental in facilitating the logical and systematic analysis,

evaluation, and interpretation of information and procedures by students (Darhim et al., 2020). In addition, this ability is acknowledged as one of the primary objectives of national and international curriculum policies that are designed to enhance higher-order thinking skills (HOTS) (NCTM, 2000; Supratman et al., 2023). Reflective and strategic thinking are influenced by critical thinking skills, which are not only essential for the correct resolution of problems but also for the meaningful application of mathematical concepts and procedures (Malik & Ubaidillah, 2020).

One of the fundamental subjects in secondary school mathematics is arithmetic, which is instrumental in the development of students' reasoning structures for advanced materials such as calculus, statistics, and algebra. As a result, it is crucial to examine critical thinking skills in the context of arithmetic, particularly in terms of how students construct arguments, evaluate numerical information, and develop solutions based on mathematical logic principles (Mhlanga, 2017; Permani & Prabawanto, 2020). In addition, students' readiness to confront more intricate numerical challenges in the workplace and in their daily lives can also be indicated by their critical thinking skills in arithmetic (Bagheri & Ghanizadeh, 2016).

There is a variety of factors that influence mathematical critical thinking skills, including gender differences, as demonstrated by numerous studies. In 2019, Sukarma et al. discovered that gender influences the cognitive style and thinking disposition of students, which in turn affects the way in which they formulate arguments and make decisions when addressing mathematical problems. In order to comprehend the potential and challenges encountered by each group, Marni et al. (2020) underscored the necessity of evaluating critical thinking skills according to gender. Even Kamid et al. (2022) observed disparities in the mathematical communication strategies and thinking structures of male and female pupils. According to a study conducted by Bagheri and Ghanizadeh (2016), there was no significant difference between males and females in inference and deduction scores. However, there was a correlation between critical thinking skills and aspects of self-regulation, such as self-monitoring. Piaw (2014) conducted an additional study that demonstrated a positive correlation between the right-brain thinking style and all aspects of creative thinking ability. Additionally, this study demonstrated that gender differences existed in the area of elaboration. Meanwhile, Shubina & Kulakli (2019) discovered that gender significantly influences both creativity and critical thinking, particularly in the context of technology and knowledge-based learning, despite the fact that the relationship between the two is intricate.

At the senior high school level, the majority of these studies did not specifically address mathematical critical thinking skills in the context of arithmetic. In addition, the methodology employed is typically quantitative and concentrates on the final outcome (product) rather than examining the cognitive processes of students based on their gender with great depth. The body of research that explicitly maps critical thinking indicators, including interpretation, inference, and evaluation, in the context of arithmetic problem-solving by male and female students remains significantly restricted. Therefore, this investigation is unique in that it provides a comprehensive examination of mathematical critical thinking indicators in arithmetic topics from a gender perspective. Not only does this method enhance the theoretical comprehension of gender-based cognitive dynamics, but it also establishes an empirical foundation for the development of learning that is more responsive, equitable, and differentiated in accordance with the diversity of learner characteristics.

Nevertheless, research in the field of gender differences in critical thinking skills continues to

yield inconsistent and varying results. Mahanal et al. (2019) indicated that gender was not a dominant factor, and differences were more pronounced based on students' academic level. In the interim, Alkharusi et al. (2019) noted that gender is indeed a predictor of critical thinking; however, its influence is significantly diminished in comparison to factors such as self-efficacy and learned strategies. In contrast, Piaw (2014) discovered that males were particularly adept at the elaboration component of creative thinking, while right-brain thinking students, who are predominantly female, were more prevalent in all aspects of creative thinking.

Other studies have also underscored the significance of pedagogical approaches that account for gender diversity. Students' critical thinking and problem-solving abilities are substantially enhanced by gender equality in mathematics classrooms, as emphasized by Nimely and Nyamu (2023). In 2019, Shubina and Kulakli demonstrated that gender influences the dynamics of both creativity and critical thinking, particularly in the context of educational technology use.

Nonetheless, the majority of these investigations are subject to significant limitations. To begin with, the majority of the studies were conducted at the university or junior secondary level and have not specifically examined high school pupils who are in a critical cognitive developmental period. The second challenge is that the domain of mathematical materials being examined is still a mixture of arithmetic, algebra, and geometry, which complicates interpretations that concentrate on the characteristics of arithmetic. Third, the cognitive processes of students have not been thoroughly examined through the analysis of critical thinking indicators, such as inference, analysis, evaluation, and reasoning, as the majority of studies continue to employ a descriptive quantitative design.

Furthermore, Suripah and Retnawati (2019) placed a greater emphasis on the creative thinking component, while the direct correlation with critical thinking has not been systematically investigated. While incorporating multivariate analysis for critical and creative aspects, Malik & Ubaidillah (2020) emphasized the influence of the experimental model and did not qualitatively investigate the influence of gender. Bagheri and Ghanizadeh (2016) conducted a study that investigated the correlation between gender and inference and deduction. However, the findings were not statistically significant and did not advance the investigation of the strategies or thinking patterns employed.

This research is novel in numerous respects due to its meticulous attention to these research gaps. First and foremost, the research is specifically focused on the development of mathematical critical thinking skills in secondary school students within the context of arithmetic topics. Secondly, this investigation not only compares the final scores of males and females, but also visualizes the critical thinking indicators that are more dominant or weakened based on gender. Third, the study integrates descriptive and exploratory methodologies to facilitate a more comprehensive examination of the cognitive dynamics of students. Fourth, it is anticipated that the findings of this investigation will make both theoretical and practical contributions to the development of mathematics learning strategies that are more equitable, differentiated, and flexible in response to the gender diversity of students.

METHOD

The mathematical critical thinking skills of high school students in arithmetic topics were analyzed using a descriptive qualitative approach in this study, which was dependent on gender. The primary goal was to investigate the manner in which students comprehend information, formulate solution steps, assess the process, and derive conclusions from non-routine problems associated with the arithmetic sequence. The qualitative data analysis technique employed in

this study was the data analysis technique outlined by Miles et al. (2014). This technique commenced with data collection through a variety of methodologies, including interviews, observation, and document analysis. Following data acquisition, the subsequent phase was data reduction, which involved the filtering and organization of data to identify pertinent patterns, themes, or categories. The reduced data were subsequently presented in a visual or narrative format, utilizing techniques such as tables, diagrams, or direct excerpts to aid in comprehension and interpretation. The final phase involved the researcher integrating the results of the analysis to form comprehensive conclusions and offer insights into the subject matter. This process was known as "drawing conclusions." The analysis was conducted using critical thinking indicators that were adapted (Facione, 2015).

Participants

This study involved students of grade X-1 in one of the high schools in Tangerang as participants. The initial number of participants was 31 students who took the mathematical critical thinking test. The subject selection technique in this study used purposive sampling, namely selection based on certain considerations related to the research objectives. Of the 31 students, 6 students were selected as the main subjects to be analyzed in depth, taking into account two aspects: gender (3 boys and 3 girls) and the category of mathematical critical thinking skills (high, medium, low). The selection was made based on the initial test results and the scores were categorized using the mean and standard deviation as the basis for classification.

Instruments

The research instruments used consisted of two types, namely test and interview instruments. These instruments have been validated by experts in their fields.

Critical Mathematics Test

The test instrument is in the form of one essay question related to arithmetic material, which is designed based on the indicators of critical thinking skills by Facione (2020). The questions given are as follows:

"A family has five children whose current ages form an arithmetic sequence. If the age of the 3rd child is 17 and the age of the 5th child is 11, then what is the sum of the ages of the five children?"

The scoring rubric was developed based on Facione (2015) which included four aspects: Interpretation, Analysis, Evaluation, and Inference, with a rating scale of 0-4 for each indicator. The categorization of mathematical critical thinking ability is as follows:

Table 2. Categorization of mathematical critical thinking skill

Classification Criteria	Category
Score ≥ Mean + SD	High
Mean – SD ≤ Score < Mean + SD	Medium
Score < Mean – SD	Low

Interviews

Six students were selected for semi-structured interviews, each of whom was from the high, medium, and low categories and represented a distinct gender. Individual interviews were conducted in a tranquil environment to ensure that students were at ease. The interview queries were intended to investigate the manner in which students comprehended the problem, devised steps, assessed responses, and drew conclusions. The interview questions were intended to elucidate the students' thought

processes as they solved the problems. Each indicator was represented by 1-2 main questions, as well as some additional exploratory questions.

Classroom Observations

The researcher conducted non-participatory observations in the classroom during the test. The objective was to document student behavior, spontaneous reactions during the process, time spent on each component of the problem, and expressions of confidence or doubt. The results of the interviews and the analysis of the test results were corroborated using this observation data as supporting data in triangulation. The context was clarified by the observation notes when students described their actions in the interviews.

Research Design and Procedures

The research procedure began with the administration of a mathematical critical thinking essay test to all 31 students of class X-1 in one of the public high schools in Tangerang. The test was designed to measure four critical thinking indicators based on Facione (2015) indicators, namely: interpretation, analysis, evaluation, and inference.

Table 2. Analytic rubric

Indicator	Sub-Indicators	Assessed Aspect
Interpretation	Identifying known and unknown information from the problem.	Mentioning that children's ages form an arithmetic sequence; recognizing U_3 and U_5.
Analysis	Design a solution by forming a mathematical model.	Using the formula Un = a + (n - 1)b and constructing a system of equations.
Evaluation	Follows solution steps and performs calculations accurately.	Perform substitution and elimination correctly to get the values of a and b.
Inference	Summarize the final result logically.	Calculates and explains the total number of ages of 5 children, and states the final conclusion.

An analytical rubric that was adapted from Facione (2015) was employed to conduct the assessment. The total score was used to classify students into three ability level categories: high, medium, and low, based on the calculation of the mean and standard deviation (SD). Each student's response was assessed by the indicators. The purposive sampling technique was employed to select six students as in-depth interview subjects after the classification process, with consideration given to their critical thinking abilities and gender variation. Three males and three females were chosen to represent high, medium, and low aptitude categories, respectively. This selection facilitated a stratified, in-depth examination of the critical thinking processes of students.

Non-participatory classroom observations were also conducted during the test to document students' behavior while working on problems, including their time management and problem-solving strategies, perseverance, and expressions of perplexity. The results of these observations served as supporting data for triangulation with the results of the test and the interview. Semi-structured interviews were conducted individually after the test was concluded and the subjects were selected. The interview is designed to delve further into the manner in which students comprehend

the issue, compile the solution steps, assess the responses, and draw conclusions regarding the final results.

Data Analysis

Data were obtained through critical thinking essay tests, semi-structured interviews, and classroom observations, then analyzed using a qualitative approach. The analysis process began with data reduction, which selected important information from student answers, interview transcripts, and observation notes. Data were categorized based on four critical thinking indicators: interpretation, analysis, evaluation, and inference (Facione, 2015). Students' answers were scored using an analytic rubric Facione (2015) with a scale of 0-4. Total scores were classified into high, medium, and low based on the mean and standard deviation (SD). Six students were purposively selected for in-depth interviews based on these categories and gender. The overall test results for students' mathematical critical thinking abilities based on gender are presented in Table 3:

Table 3. Test results by gender

No	Mathematical Critical Thinking Category	Male	Female
1	High	1	2
2	Medium	4	11
3	Low	9	5
Total		14	17

The findings indicate that female students tend to have higher mathematical critical thinking abilities than male students. The calculation of the analysis results was separated between male and female students and then sorted based on the high, medium, and low categories. The study involved 31 students, comprising 14 male students and 17 female students. Interviews were analyzed using thematic coding to find students' thinking patterns. Data from tests, interviews, and observations were compared through triangulation to increase validity. The final results were analyzed narratively to describe students' critical thinking skills as a whole.

■ RESULT AND DISCUSSION

Mathematical Critical Thinking Ability of High School Students in Arithmetic Sequences and Series Based on Gender Differences

The results suggest that female students generally demonstrate stronger critical thinking performance than male students. The calculation of the analysis results was separated between male and female students and then sorted based on the high, medium, and low categories. The study involved 31 students, comprising 14 male students and 17 female students.

Critical Thinking Skills in Male Students with a High Category

The description of the test results and interviews with male students in the high category led to the selection of Student Code S-1, who represents a high level of critical thinking skill.

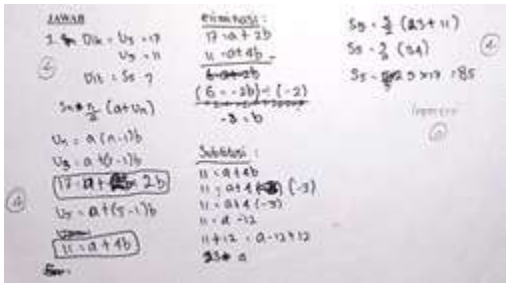

Figure 1. Student response code S-1

Student Interview Excerpt (Student Code S-1)

P: Can you explain how you understood the problem before you started solving it?

S-1: I saw the information given, like $U_3 = 17$

and $U_5 = 11$. I knew this was an arithmetic sequence, therefore I proceeded to write the formula and tried to find the pattern.

P: Did you think about the relationship between Uf and U… before writing the formula?

S-1: Hmm... no. The problem is that I know that if there are two Un values, I can usually find a and b directly. So I just put them into the formula, not really thinking about the relationship.

P: How do you determine the solution steps after knowing the general form of the formula?

S-1: I wrote an equation based on the formula $Un = a + (n-1)b$. Then I created two equations for $U_3 = 17, U_5 = 11$, and tried to solve them with elimination and substitution.

P: Did you consider other ways besides forming a system of equations?

S-1: Actually, you can also use the difference between terms, but I am more confident in using this method because it is more certain and I usually use it in practice.

P: Did you check your answer after calculating it?

S-1: Yes, I deleted some parts because I felt there was an error in the calculation. I tried to recalculate to make sure the result was correct.

P: After you fix it, how do you know that your answer is correct?

S-1: I tried to check the value again by entering it into the formula. If the result matches Uf and U…, then it's correct. But I didn't write down all the steps, I just checked them in my mind.

P: After obtaining the final result, are you sure of your answer? Can you summarize the final result?

S-1: I was sure about the answer because I used the arithmetic series sum formula. But I forgot to write the final conclusion, I just stopped at the calculation S_5.

P: Why do you think it's important to write a conclusion?

S-1: So that other people can understand what the answer means. But I often forget because I focus on the calculation.

The analysis of high-category male students (S-1) revealed that their critical thinking skills were proficient in the areas of mastery of concepts and application of procedures, but they were still restricted in the areas of exploration, reflection, and mathematical communication. The general formula was promptly applied by the students without difficulty, and they were able to identify that the problem was related to the arithmetic sequence. However, the approach employed was very procedural, as it was based on habit rather than a critical evaluation of various potential strategies. This is indicative of the typical learning style of male students, who are visual-procedural in nature. They are inclined to think swiftly and directly to the solution, while they pay less attention to the process of in-depth analysis or alternative strategies (Mhlanga, 2017). S-1 selected the elimination-substitution method for the problem because it felt the most secure, rather than because it logically assessed the other methods. This indicates that the capacity for flexibility, which is a fundamental component of critical thinking, has not been fully realized. The results were assessed mentally, without explicit documentation, indicating that students rarely formulate mathematical arguments in written form. This supports the results of Alkharusi et al. (2019), who emphasized the significance of metacognitive training in enhancing students' evaluative awareness in the development and dissemination of solutions. The student acknowledged the significance of drawing conclusions; however, he refrained from doing so in writing due to his preoccupation with the calculation result rather than the integrity of the answer presentation. This was a common pattern among many male students who employed conventional learning methods. S-1's performance remains stagnant at the technical level, with no extension of reflective

thinking skills, in contrast to students who engaged in exploration-based learning, such as RICOSRE (Mahanal et al., 2019) or MSLAM (Malik & Ubaidillah, 2020). As a result, despite the fact that this student is classified as academically high-ability, his critical thinking skills have not been fully developed as a result of the influence of learning styles, gender characteristics, and learning models that have not facilitated the exploration and documentation of active and structured thinking.

Critical Thinking Skills in Male Students with a Medium Category

The test results and interview description of a male student in the medium category, represented by Student Code S-8, were analyzed in-depth to examine the student's mathematical critical thinking ability.

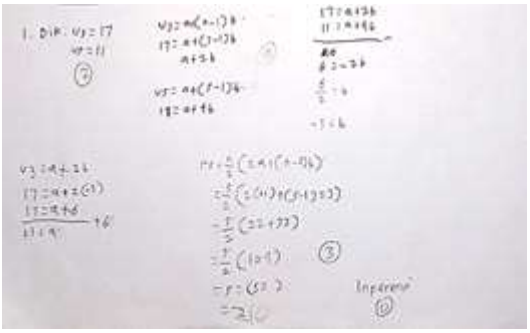

Figure 2. Student response code S-8

Student Interview Excerpt (Student Code S-8)

P: How did you understand the problem before you started solving it?

S-8: I saw that the problem gave the 3rd term (U_3) and the 5th term (U_5) I knew this was an arithmetic sequence, so I used the formula $Un = a + (n - 1)$ to find the values of a and b.

P: How do you determine the steps of the solution after understanding the formula?

S-8: I wrote two equations based on the values of U_3 and U_5, then used the elimination method to find the values of and . After that, I substituted the values into the formula for the sum of the first five terms to get the final result.

P : Did you verify your calculations?

S-8: I corrected some parts, but I believe the final result is correct because I followed the formula I learned.

P: Can you explain the conclusion of your answer?

S-8: I obtained the result , but maybe I didn't write the conclusion explicitly. I just stopped at the final result without stating a clear conclusion.

The moderate male student (S-8) exhibited a procedural mathematical thinking pattern, but he lacked conceptual profundity and systematicity. He was capable of identifying the nature of the problem and employing the arithmetic sequence formula, such as S-1. However, he was unable to logically and comprehensively integrate the problem information into a mathematical model. His analysis was characterized by a lack of process rigor and a focus on results, which is indicative of the inclination of moderate category students to rely on technical intuition and memorization (Basri et al., 2019; Mhlanga, 2017). The evaluation of S-8 was also superficial, as it was based on beliefs that were based on formulas rather than systematic logical substantiation. This was in contrast to S-1, who, despite not yet being explorative, had demonstrated evaluative initiatives. S-8 did not expressly draw a conclusion from the results, suggesting that the habit of reflective thinking had not yet been established. Although S-1 comprehended the significance of inference, he was inconsistent in his documentation. This discrepancy suggests that critical thinking is significantly influenced by self-regulation, reflective habituation, and learning experiences. This finding is further supported by the research conducted by Supratman et al. (2023), which indicates that the contribution of critical thinking to the learning outcomes of males is lower (59.1%) than that of females (81.6%).

This suggests an inequality in the profundity of thinking based on gender. Furthermore, a study conducted by Permani and Prabawanto (2020) demonstrated that female students were more systematic and cautious in their problem-solving process, despite the fact that both male and female students met the critical thinking indicators.

Therefore, despite the fact that S-1 and S-8 both exhibited fundamental differences in the profundity of analysis, reflection, and communication of ideas, although they both exhibited basic procedural skills. These findings are consistent with a variety of studies that underscore the significance of reflection-based learning approaches, including Problem-Based Learning and RICOSRE (Darhim et al., 2020), in the comprehensive development of critical thinking dimensions, particularly in male students who are inclined to prioritize the end result over the thinking process

Critical Thinking Skills in Male Students with a Low Category

The test results and interview description of a male student in the low category, represented by Student Code S-11, were analyzed in-depth to examine the student's mathematical critical thinking skills.

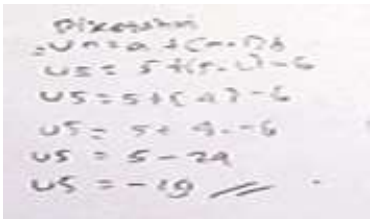

Figure 3. Student response code S-11

Student Interview Excerpt (Student Code S-11)

P: Can you explain how you understood the problem before you started solving it?

S-11 : I saw that this question was about arithmetic sequence, so I wrote down the general formula to find the nth term. I tried to use the formula $Un = a + (n-1)b$ to determine the required term.

P : How do you determine the solution steps after knowing the formula?

S-11: I wrote the equation based on the formula, then tried to find the relationship between the values given. I performed algebraic operations to arrive at a solution.

P : Did you verify your calculations?

S-11: Not really. I think my answer is correct because I followed a formula I had previously learned.

P: Can you explain the conclusion of your answer?

S-11: Actually, I didn't write a conclusion. I arrived at the final result but did not state the conclusion explicitly.

A minimal conceptual comprehension and a highly procedural thinking pattern were exhibited by the male student in the low category (S-11). He was able to identify the problem type as an arithmetic sequence and transcribe the formula 5ØHÜ5Ø[Ü=5ØNÜ+(5Ø[Ü"1), but he was unable to connect the information to the logical structure of the problem and did so solely through memorization. Basri et al. (2019) have observed that his errors in algebraic operations are indicative of a lack of analytical and computational skills, as well as a disarray in the organization of information. These are typical patterns among students in the low critical category. The result was deemed correct solely because he "followed the formula," and the absence of verification and evaluation of his answer demonstrated a lack of metacognitive regulation and reflection. In contrast, S-8, despite their limitations, had demonstrated efforts to model and make corrections. S-11 did not provide a conclusion in the inference area, suggesting that he had not yet developed the habit of logical communication in problem-solving. When contrasted with S-1, the distinction is even more apparent: S-1 has demonstrated evaluative initiative and an understanding of the significance of inference,

despite not yet being entirely exploratory. This disparity is indicative of the aptitude level, as well as the quality of self-regulation, learning experience, and the habituation of reflective thinking. The findings of Supratman et al. (2023) are in agreement with these findings, which indicate that the contribution of critical thinking to the learning outcomes of male students was lower than that of female students, particularly in the areas of evaluation and inference. The low ability of S-11 can be attributed to the dominance of rote-based learning and the absence of explorative stimulus. Consequently, in order to facilitate the development of his critical thinking skills, an approach that prioritizes mathematical communication, logical verification, and reflection is required.

Critical Thinking Skills in Female Students with a High Category

The test results and interview description of a female student in the high category, represented by Student Code S-29, were analyzed in-depth to examine the student's mathematical critical thinking ability. This analysis also identified the challenges faced when solving test problems, covering the four critical thinking indicators.

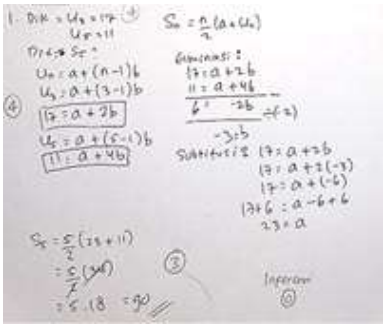

Figure 4. Student response code S-29

Student Interview Excerpt (Student Code S-29)

P: Can you explain how you understood the problem before you started solving it?

S-29: I saw that this problem was about an arithmetic sequence, so I first identified the terms given. Because of $U_3 = 17$ and $U_5 = 11$, I knew I had to find the values of aaa and bbb before calculating the sum of the first five terms.

P: How did you determine the steps to solve the problem?

S-29 : I used the general formula of the nth term, $Un = a + (n-1)b$. After that, I formed two equations based on U_3 and U_5, then solved them using the elimination and substitution method to find a and b.

P: Did you verify your calculations?

S-29: Not really. I was sure that my steps were correct, so I went ahead and calculated the sum of the first five terms.

P: What about your conclusion? Can you explain the final result?

S-29: I got $S_5 = 90$, but I forgot to write the conclusion. I thought the answer was clear from the final result of the calculation.

Strong critical thinking abilities were demonstrated by the female student in the high category (S-29), particularly in the areas of interpretation and analysis. By employing an appropriate mathematical model, she was capable of systematically designing the solution steps, comprehending the purpose of the calculation, and identifying critical information from the arithmetic sequence problem. Contrary to the high-category male student (S-1), who appeared to rely more on procedural habit patterns without investigating the relationship between information, S-29 appeared to be more reflective and structured in her solution construction. Nevertheless, both exhibited comparable deficiencies in evaluation and inference, such as failing to carry out final verification and failing to explicitly state conclusions. This implies that, despite their robust logical thinking, their reflective habits and logical communication have not yet been completely developed. Gender-based thinking patterns may

account for this disparity, as female students are more meticulous and methodical (Sukarma et al., 2019), whereas male students are more rapid in their execution but lack conceptual exploration. Research conducted by Supratman et al. (2023) corroborates this assertion by demonstrating that the contribution of critical thinking to the learning outcomes of female students is higher than that of male students (59.1%). Furthermore, these findings are consistent with the findings of Malik & Ubaidillah (2020), which underscore the importance of a reflection-based learning approach in the enhancement of critical thinking skills, particularly in female students who are more receptive to learning processes that prioritize conceptual meaning and exploration. Female students are more adept at developing structural understanding and process awareness, while male students are more technically proficient. However, both students require further development in the areas of evaluative and inferential thinking through reflective learning models. This is the emergent pattern.

Critical Thinking Skills in Female Students with a Medium Category

The test results and interview description of a female student in the medium category, represented by Student Code S-19, were analyzed in-depth to examine the student's mathematical critical thinking skills.

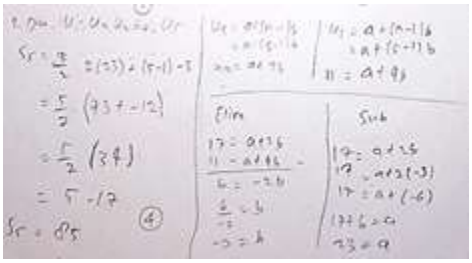

Figure 5. Student response code S-19

Student Interview Excerpt (Student Code S-19)

P: Can you explain how you understood the problem before you started solving it?

S-19: I saw that this problem was about arithmetic sequence, so I started by writing down the formula for the nth term and identifying the given terms. Since the problem asked for the sum of the first five terms (S_5), I knew I had to find the values of a and b first before calculating the sum.

P: How did you determine the solution steps?

S-19: I used the formula $Un = a + (n-1)b$ to create two equations using the values of U_3 and U_5. Then, I used the elimination method to find a and b. After getting the values, I substituted them into the arithmetic series sum formula to calculate .

P: Did you verify your calculations?

S-19: I was confident in my solution because I followed a formula that I memorized, so I went straight to the final result without double-checking.

P: What about your conclusion? Can you explain the final result?

S-19: I obtained , but I didn't write down the conclusion. I believed the final result was self-explanatory.

The medium category female student (S-19) exhibited strong critical thinking abilities, particularly in the areas of interpretation and analysis. Using a mathematical model and the elimination method, she was able to accurately design a solution strategy and identify the critical components of the arithmetic sequence problem. Although her approach was less structured than that of a high-category student such as S-29, it was more systematic than that of a medium-category male student (S-8), who tended to be less methodical and procedural. Mahanal et al. (2019) have found that the learning model is more effective in developing the critical thinking skills of female students because they are more responsive to coherent and explorative thinking processes. This is supported by the fact that female students tend to organize information more neatly and reflectively. This distinction in methodology is also evident in the evaluation aspect: S-19 and S-29 did not verify the final

results, but the rationale was distinct from that of the male students. The girls believed that their process was sufficiently transparent, whereas the boys were more inclined to expedite procedures. This evaluation deficit is indicative of inadequate metacognition, as noted by Alkharusi et al. (2019), who also discovered that cognitive strategies and self-regulation are significant factors in the quality of students' critical thinking. Similarly to students of all categories, S-19 did not expressly record the conclusion in terms of inference. However, female students appear to regard the calculation results as indicative of their comprehension, whereas male students tend to disregard this communicative aspect. This pattern implies that the medium-category female students displayed a more reflective and coherent thinking structure than the male students in the same category, despite the fact that they had not achieved the same level of analysis as the high-category students. Consequently, the discrepancy in outcomes between S-8 and S-19 is more affected by factors such as cognitive structure, sensitivity to process, and thinking style. These factors can be enhanced through reflection-based learning to enhance critical thinking capacity across gender and aptitude levels.

Critical Thinking Skills in Female Students with a Low Category

The test results and interview description of a female student in the low category, represented by Student Code S-15, were analyzed in-depth to examine the student's mathematical critical thinking skills.

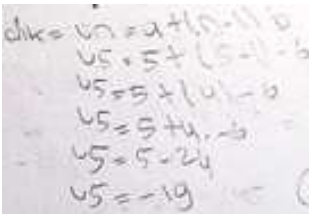

Figure 6. Student Response Code S-15

Student Interview Excerpt (Student Code S-15)

P: Can you explain how you understood the problem before you started solving it?

S-15: I saw that this question was about an arithmetic sequence, so I tried to use the general formula for the nth term to find the required term. I also saw that I had to determine the value of U_5 , therefore I proceeded to write the formula.

P: How did you determine the steps to solve the problem?

S-15: I used the formula $Un = a + (n-1)b$, then I substituted the known values. After that, I calculated the result.

P : Did you verify your calculations?

S-15: No, I went straight to the final answer. I thought the formula I used was correct.

P: Does your final answer match what is asked in the question?

S-15: I got $U_5 = -19$, but I'm not too sure if it's correct. I also didn't write a conclusion at the end.

The female pupil from the low category (S-15) exhibited a lack of critical thinking skills and was exceedingly procedural. Without making any attempt to logically connect the information provided to the context of the problem, she was able to identify the problem as an arithmetic sequence and promptly applied the formula $Un=a+(n-1)b$. Memorization was the foundation of the solution process, which was not preceded by an analysis of the information structure or accompanied by the conscious formulation of a system of equations. The moderate (S-19) and high (S-29) female students were able to compile the steps more coherently, despite still exhibiting deficits in evaluation and inference. This is a significant contrast. S-15 exhibited a comparable pattern of thought to the low-category male student (S-11), going directly to the procedure without verification. However, she exhibited a reduced awareness of the

ambiguity of her answer, which can be interpreted as the onset of metacognitive awareness. S-15's failure to expressly conclude the results and not double-check the evaluation and inference aspects suggests a lack of reflection on the thinking process. This result is consistent with the research findings of Sitanggang et al. (2020), which demonstrated that students who lack critical thinking skills are more likely to struggle with strategizing and are unable to independently evaluate their mathematical decisions. Tekin et al. (2021) also substantiate this claim, asserting that students who do not receive thinking scaffolding or exploration-based learning are more likely to become imprisoned in mechanical patterns and fail to develop cognitively.

In comparison to the findings of previous research, S-15's critical thinking abilities are comparable, and in certain respects, they may even be inferior, particularly in terms of the absence of explicit reflection, ambiguity in responses, and the absence of a thinking structure. There is evidence from prior research that even students with limited abilities can make progress when they are exposed to learning that promotes logical communication and open-ended reasoning. The results of S-15 did not demonstrate any substantial improvements in inference or evaluation. Consequently, it is probable that the learning she underwent was procedural and did not stimulate the development of critical thinking. Consequently, this pattern indicates the necessity of pedagogical interventions that are structured around mathematical communication strategies, supervised discussion, and reflection in order to enable students in the low category, such as S-15, to establish more metacognitively developed, logical, and conscious thinking structures.

■ CONCLUSION

The findings of this study revealed gender-based disparities in the mathematical critical thinking abilities of senior high school pupils with respect to the arithmetic sequence. In general, female pupils exhibit superior critical thinking abilities in comparison to their male counterparts, particularly in the areas of interpretation and analysis. Female students are more thorough and systematic in their approach to problem-solving, despite the fact that they often require more time. Conversely, male students are able to solve problems more rapidly, but they struggle to clearly articulate the steps involved in the solution. The majority of students neglected to examine their responses during the evaluation phase, which resulted in the failure to identify minor errors. Furthermore, a significant number of students did not explicitly present conclusions that were derived from their calculations in the inference section. Based on the category of critical thinking ability, the proportion of female students in the high category is higher, while male students are more prevalent in the low category. The majority of students fell into the medium category, suggesting that their mathematical critical thinking abilities require further development. Consequently, in order to enhance the development of students' mathematical critical thinking skills, it is necessary to implement more suitable learning strategies that are tailored to the unique characteristics of each gender, encourage students to be more meticulous in evaluating their responses, and increase the practice of drawing conclusions.

■ REFERENCES

Alkharusi, H. A., Sulaimani, H. Al, & Neisler, O. (2019). Predicting critical thinking ability of Sultan Qaboos University students. *International Journal of Instruction*, *12*(2), 491–504. https://doi.org/10.29333/iji.2019.12231a

Bagheri, F., & Ghanizadeh, A. (2016). Critical thinking and gender differences in academic self-regulation in higher education. *Journal of Applied Linguistics and Language Research*, *3*(3), 133–145. www.jallr.com

Basri, H., Purwanto, As'ari, A. R., & Sisworo. (2019). Investigating critical thinking skill of junior high school in solving mathematical problem. *International Journal of Instruction*, *12*(3), 745–758. https://doi.org/10.29333/iji.2019.12345a

Darhim, Prabawanto, S., & Susilo, B. E. (2020). The effect of problem-based learning and mathematical problem posing in improving student's critical thinking skills. *International Journal of Instruction*, *13*(4), 103–116. https://doi.org/10.29333/iji.2020.1347a

Facione, P. a. (2015). Critical thinking/ : what it is and why it counts. In *Insight assessment*. https://www.insightassessment.com/CT-Resources/Teaching-For-and-About-Critical-Thinking/Critical-Thinking-What-It-Is-and-Why-It-Counts/Critical-Thinking-What-It-Is-and-Why-It-Counts-PDF

Kamid, K., Fajriah, N., Kurniawan, D. A., & Widodo, R. I. (2022). Elementary school students' mathematical process skills in gender perspective. *International Journal of Elementary Education*, *6*(2), 223–231. https://ejournal.undiksha.ac.id/index.php/IJEE/article/view/45219

Mahanal, S., Zubaidah, S., Sumiati, I. D., Sari, T. M., & Ismirawati, N. (2019). RICOSRE: A learning model to develop critical thinking skills for students with different academic abilities. *International Journal of Instruction*, *12*(2), 417–434. https://doi.org/10.29333/iji.2019.12227a

Malik, A., & Ubaidillah, M. (2020). Students critical-creative thinking skill: A multivariate analysis of experiments and gender. *International Journal of Cognitive Research in Science, Engineering and Education*, *8*(Special Issue 1), 49–58. https://doi.org/10.23947/2334-8496-2020-8-SI-49-58

Marni, S., Aliman, M., Suyono, S., Roekhan, R., & Harsiati, T. (2020). Students' critical thinking skills based on gender and knowledge group. *Journal of Turkish Science Education*, *17*(4), 544–560. https://doi.org/10.36681/tused.2020.44

Mhlanga, M. T. (2017). Students' critical ability in solving mathematics problem based on gender differences. *International Journal of Science Arts and Commerce*, *1*(1), 67–74. www.ijern.com

Miles, M. B., Huberman, A. M., & Saldana, J. (2014). Qualitative data analysis. SAGE Publications. https://books.google.co.id/books?id=3CNrUbTu6CsC

NCTM. (2000). *Principles and Standards for School Mathematics*. NCTM.

Nimely, D. R., & Nyamu, F. K. (2023). Influence of psychological well-being and school factors on delinquency , during the covid-19 period among secondary school students in selected schools in nakuru county/ : Kenya. *International Journal of Research and Innovation in Social Science*, *7*(7), 1446–1454. https://doi.org/10.47772/IJRISS

Permani, K. D., & Prabawanto, S. (2020). Analysis of students ' mathematical critical thinking based on gender in the topic of linear programming. *The 2nd International Conference on Elementary Education*, *2*(1), 1882–1890.

Piaw, C. Y. (2014). Effects of gender and thinking style on student's creative thinking ability. *Procedia - Social and Behavioral Sciences*, *116*, 5135–5139. https://doi.org/10.1016/j.sbspro.2014.01.1087

Shubina, I., & Kulakli, A. (2019). Critical thinking, creativity and gender differences for knowledge generation in education. *Literacy Information and Computer Education Journal*, *10*(1), 3086–3093. https://doi.org/10.20533/licej.2040.2589.2019.0405

Sitanggang, S. L., Syahputra, E., & Yus, A. (2020). The effect of problem based learning model on critical thinking ability student mathematics and adversity student quotient on students SMP Negeri 4 Lubukpakam. *Budapest International Research and Critics in Linguistics and Education (BirLE) Journal*, *3*(4), 1814–1822. https://doi.org/10.33258/birle.v3i4.1374

Sukarma, I. K., Budayasa, I. K., & Suwarsono. (2019). Gender, cognitive style, and its relationship with critical thinking: a literature review. *IOSR Journal of Research & Method in Education (IOSR-JRME)*, *9*(5), 62–67. https://doi.org/10.9790/7388-0905046267

Supratman, Zubaidah, S., Tarigan, M. R. M., & Azis, S. (2023). Contribution of critical thinking, science process skills towards learning outcomes based on gender. *International Journal of Evaluation and Research in Education*, *12*(4), 1985–1993.

Suripah, S., & Retnawati, H. (2019). Investigating students' mathematical creative thinking skill based on academic level and gender. *International Journal of Scientific and Technology Research*, *8*(8), 227–231.

Tekin, N., Kepceoðlu, Ý., Ýpekoðlu, A., & Bülbül, A. (2021). International journal of psychology and educational studies analysis of the mathematical thinking levels of individual and team athletes in terms of different variables. *International Journal of Psychology and Educational Studies*, *8*(2), 148–157. www.ijpes.com