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Uncovering Gender-Role Differences in Reflective Thinking: A Qualitative Study of Prospective Teachers Solve Open-Ended Mathematics Problems

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Abstract

Reflective thinking is a critical cognitive process that supports students in analysing, monitoring, and evaluating their reasoning when solving mathematical problems. This study aims to reveal differences in prospective teachers' reflective thinking when solving open-ended mathematics problems. This qualitative case study involved two prospective teachers representing masculine male and feminine female gender-role orientations. Subjects were selected based on a gender questionnaire and mathematical ability. Instruments included a gender questionnaire, problem-solving tasks, and semi-structured interviews. Data were analysed through classification, reduction, presentation, interpretation, and conclusion drawing, with credibility ensured through time triangulation. The results indicate that the masculine male participant demonstrated a more systematic and complete reflective thinking profile, articulated logical justifications, and explored alternative strategies. In contrast, the feminine female participant presented incomplete and unsystematic steps, with limited logical reasoning and strategic variation. These findings show that gender-role orientation qualitatively influences reflective thinking in solving open-ended problems. This study contributes to Sustainable Development Goal 4 (Quality Education) by providing insights for designing gender-responsive and adaptive mathematics instruction to strengthen prospective teachers' reflective thinking and promote equitable learning quality.

Keywords: Gender, Open-ended, Reflective thinking
SDGs: Goal 4 (Quality Education), Goal 5 (Gender Equality)

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INTRODUCTION

In the teaching and learning process, teachers are a key component and play a strategic role in shaping the future of the next generation. Teachers are also agents of change for the success of the education system (Brown et al, 2021). The quality of education is greatly influenced by the quality of teachers, making the education of prospective teachers an integral aspect of quality improvement efforts. Every undergraduate graduate is required to possess general skills, including logical, critical, systematic, and innovative thinking, which are also required of prospective mathematics teachers. Reflective thinking is an integral part of the creative and critical thinking process.

During reflective thinking, a person evaluates their existing knowledge and recognizes the need to bridge existing gaps (Tuononen et al, 2023), including modifying their understanding (Merkebu et al, 2024). This process involves self-exploration, enables perspective transformation, and fosters problem-solving skills (Tang et al., 2023). Reflective thinking is an active cognitive activity (Li et al, 2024) and is related to an individual's

beliefs and attitudes (Guo et al, 2022; Asare, 2025). Reflective thinking is a form of conscious thinking (Sailer et al, 2021), a critical self-examination (Orakci, 2021), and includes self-dialogue and testing (Procter, 2020). Reflective thinking helps individuals control themselves in solving problems, leading to more effective solutions. Reflective thinking leads to careful reconsideration (Soto-González et al, 2023), detailed analysis, disciplined and meticulous execution (Tobin et al, 2025; Kasalak et al, 2022).

Throughout reflective thinking activities, a person provides logical reasons for what they do (Azimi et. al, 2023), identifies strengths and weaknesses (Harvey et al, 2025), and does something involving elements of analysis (Al-Rashidi & Aberash, 2024). The reflective thinking process involves systematic thinking (Göğüş et al., 2020), and has cyclical and recursive elements (Muhammed et al., 2022). The ability to make decisions is also an important part of reflective thinking (Ocak et al., 2020). Furthermore, the final part of the reflective thinking process is re-evaluating the strategies used, questioning the chosen method, and choosing the right method (Li, 2025). Reflective thinking also means evaluating solutions and choosing the best solution (Toraman et al., 2020).

Research by Putriani & Purnomo (2025) shows that men's reflective thinking in problem-solving tends to be pragmatic, using trial and error, while women tend to be analytical. Furthermore, women often consider the emotional dimension, while men focus on effectiveness and efficiency. Men tend to be more independent, self-reliant, and seek external help as a last resort. Meanwhile, women tend to be cooperative, involving external parties to seek feedback and broaden their perspectives (Sa'dijah et.al., 2021). Gender differences influence rational reflection. Women are more likely to respond intuitively incorrectly than men. Women tend to jump to conclusions (Cristina, 2021).

Previous studies present inconsistent findings regarding gender differences in mathematical problem solving. Borgonovi et al. (2023) report that women tend to excel in collaborative problem-solving due to stronger social competencies, whereas men perform better in individual contexts. However, Vos et al. (2023) found no significant gender differences in overall mathematical problem-solving performance, although women reported higher levels of mathematics anxiety. These contrasting results suggest that gender differences may not lie in cognitive ability per se, but rather in contextual factors, affective variables, and task characteristics, indicating the need for more process-oriented investigations.

Open-ended problems can foster students' reflective thinking by encouraging them to view problems from multiple perspectives and generate diverse as well as elegant solutions (Lee et al, 2026; Kholid et al, 2024). Critical thinking is strengthened through logic-based problem solving, the use of open-ended problems can also enhance students' reflective thinking skills. Previous research has revealed numerous gender differences in reflective thinking in problem-solving. However, few have explored the extent to which gender differences influence the reflective thinking process in solving non-routine, open-ended problems. Therefore, the novelty of this study is the reflective thinking process of individuals when faced with open-ended mathematical problems involving linear equations and inequalities. The results can be used to measure the ability to provide logical reasoning, explore alternative strategies, and offer new perspectives for the development of gender-based pedagogical interventions. This aligns with two of the SDGs goals: quality education and gender equality.

The purpose this study is investigates differences in prospective teachers' reflective thinking when solving open-ended mathematics problems. Unlike prior research that examines reflective thinking or gender differences separately, this study applies a process-tracing approach to analyse micro-level reflective phases while conceptualising gender through gender roles (masculine and feminine traits), not merely biological sex. By integrating process tracing, open-ended problem contexts, and gender role orientation, this research highlights how internalised gender roles shape reasoning structure, logical justification, and strategic flexibility in mathematical problem-solving.

METHOD

This research is descriptive with a qualitative approach. Subjects were selected from a group of prospective mathematics teacher students at a university with relatively similar mathematical abilities and in the same semester. This study employed an in-depth qualitative case analysis; therefore, one subject per gender-role category was considered sufficient to capture rich, detailed process-tracing data rather than to achieve statistical generalization. The focus of analysis was depth of cognitive process reconstruction, which required intensive examination of each participant's reflective episodes. Androgynous and undifferentiated categories were excluded to avoid interpretative overlap and to maintain analytical sharpness.

The primary instrument was the researcher. While the supporting instruments were a questionnaire to determine gender, an open-ended mathematics problem-solving task (PST), and an interview guide. The gender instrument was adapted from an instrument developed by Spence et al. (1978), namely the PAQ (Personal Attribute Questionnaire). The PAQ measures gender-role orientation based on socially constructed masculine and feminine traits rather than biological sex. It consists of bipolar characteristic items rated on a Likert scale, producing separate masculinity and femininity scores. There are three PSTs validated by experts.

The interview guide was designed to explore participants' reflective thinking processes during problem solving, particularly in the phases of planning, monitoring, evaluating, and revising their solutions. The questions were semi-structured, allowing probing questions to clarify reasoning patterns, decision-making processes, and the exploration of alternative strategies. The interviews also aimed to capture how participants justified their answers and responded to cognitive conflicts encountered while solving the open-ended task. Data collection was carried out through documentation and interviews. Data were validated using a credibility test with time triangulation. Credibility was ensured through data triangulation between written problem-solving results and in-depth interviews, as well as member checking to confirm the accuracy of participants' statements. Dependability was established by maintaining a clear audit trail documenting the research procedures, coding process, and analytical decisions. Data analysis was carried out through classification, reduction, presentation, interpretation, and conclusions for each stage of problem-solving (Polya, 1973). The research procedure is as in Figure 1.

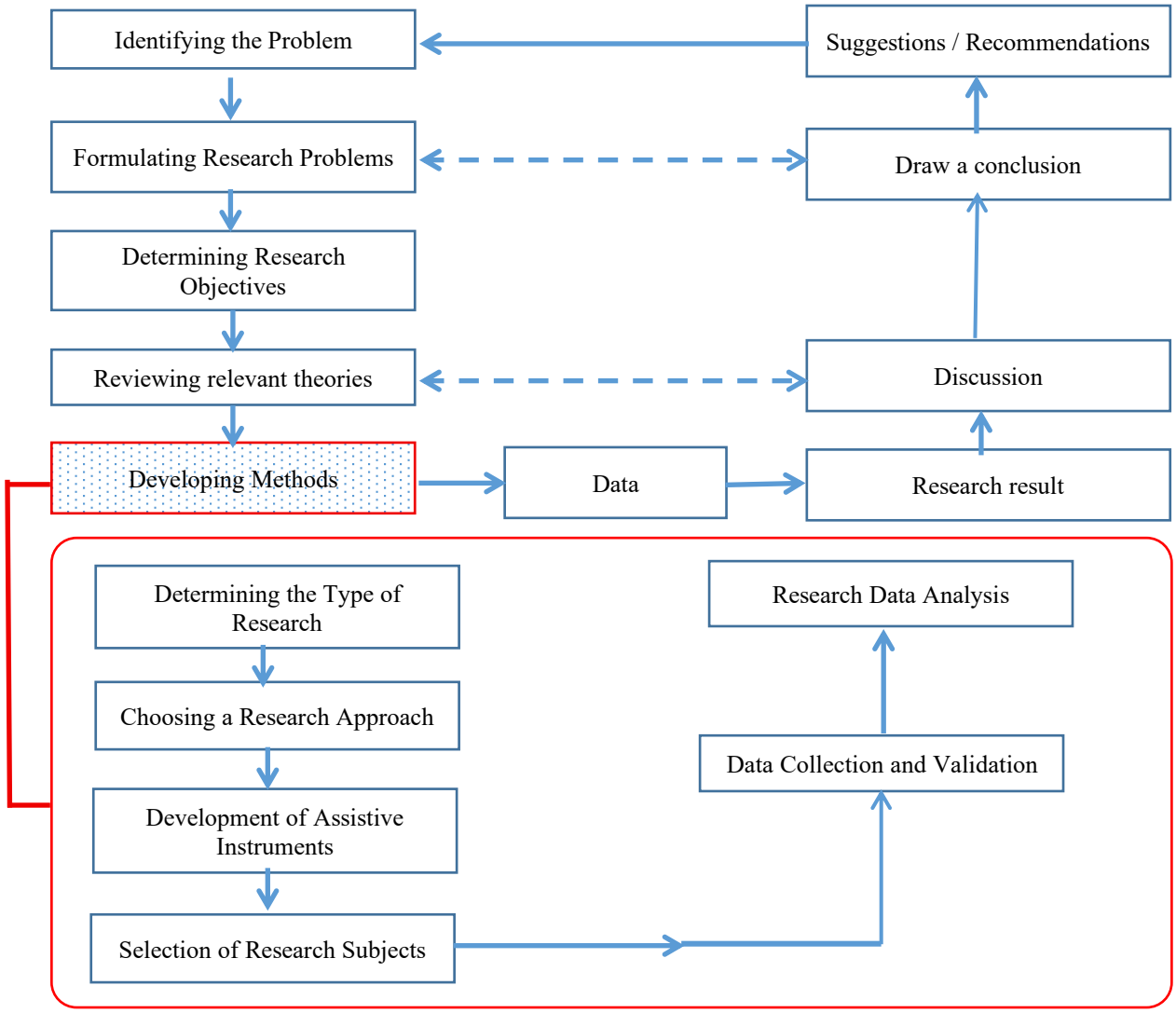


Figure 1. Research Procedure

The indicators of reflective thinking in this paper are rethinking what has been done (I_1), doing something correctly (I_2), stating it completely (I_3), stating reasons logically (I_4), taking steps systematically (I_5), making decisions (I_6), and reviewing the chosen strategy/answer (I_7). The PST given is as follows.

> *A disaster volunteer team consisting of 15 people will conduct a rescue. There are two routes that can be taken to reach the location: a 6.2 km macadam path and a 4.2 km protected forest path. Based on experience, a person needs 1 bottle of mineral water to cover 1.5 km of macadam path and 2 bottles of mineral water to cover 1 km of protected forest path. The team will be divided into two groups that will take different routes. 4 boxes of mineral water are available, each box containing 24 bottles. The mineral water bottles are divided in an intact state or the caps cannot be opened. How should the team be divided for the two routes? Determine possible solutions! Which solution is best so that the remaining mineral water bottles are the least?*

RESULTS AND DISCUSSION

To obtain two subjects, a group of undergraduate students in the Mathematics Education Study Program were asked to complete a gender questionnaire. The results of the subject selection are as in Table 1.

Table 1. Subject Selection Results

Questionnaire	Number of Respondent	Number of MM	Number of FF	Number of Androgyny
First questionnaire	82	4	43	35
Second questionnaire	46	2	34	10
Third questionnaire	34	2	27	5

Inf: MM = Masculine Male, FF = Feminine Female

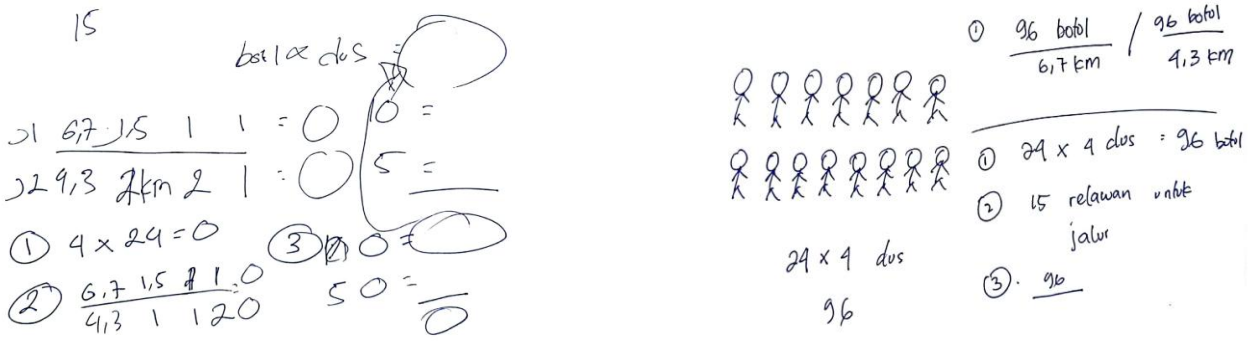
Use of the first, second and third questionnaires in Table 1 was intended to determine the consistency of the answers of potential subjects. To determine potential subjects, from the results of the third questionnaire, students with relatively similar mathematical abilities were selected, resulting in 1 masculine male student and 1 feminine female student. The supporting instrument in the form of Problem-Solving Tasks (PST) was developed by the researcher and validated by 3 experts. Data collection was carried out through in-depth interviews while the subjects were working on the PST. After interviews with PST 01 and PST 02, the data were validated. If there was invalid data, interviews were conducted with PST 03, PST 04, PST 05, and so on until valid data was obtained. It turns out that valid data was obtained after TPM 03 interview. The reflective thinking process is described according to the stages of problem solving.

Understanding the Problem Stage

At this stage, the masculine male student's reflective thinking process is characterized by his ability to restate what is known in the PST and what is asked. In restating the information, the masculine male student presents it out of sequence. He randomly presents whatever comes to his attention while looking at the PST given. Meanwhile, the feminine female student restates what is known and what is asked sequentially. She simply repeats the information by reading the PST. This makes it appear more structured. Similarly, when indicating which parts are known and which parts are asked, the masculine male student presents it randomly, while the feminine female student presents it sequentially.

Planning Solution Stage

At this stage, the reflective thinking process of masculine male students is characterized by mentioning the steps to plan a solution correctly, mentioning the steps to plan a solution completely, giving logical reasons that if the planning steps are carried out then the problem will be solved and the masculine male student conveys the planning steps systematically. Meanwhile, in feminine female students, the reflective thinking process is characterized by being unable to mention correctly related steps to plan a solution, being unable to mention the steps to plan a solution completely, being unable to provide logical reasons that if the planning steps are carried out then the problem will be solved and the feminine female student carries out the planning steps unsystematically. The difference at planning solution stage can be seen in Figure 2.



Masculine Male Feminine Female

Figure 2. Differences in plans for solving open-ended problems

Figure 3 shows that masculine male students can correctly state the steps for planning a solution. Although using trial and error, the chosen steps can be used to complete the given problem-solving task. During this reflective thinking process, a masculine male student is able to control himself to articulate the chosen strategy. He is also able to communicate ideas abstractly, assess what has been written in the plan, do it consciously and correct any errors (Chamdani et al., 2022). Meanwhile, a feminine female student cannot correctly articulate the steps for planning a solution. She feels confused about what to do to solve the problem in the given PST (Setiyani et. al, 2025). She is also unable to critically examine herself, whether the steps presented are correct or not. She appears hesitant, so she is unable to consider herself, is unable to test her own opinions, and is unable to supervise herself. This contradicts the opinion of Orakci (2021) who stated that during the reflective thinking process, the process of self-consideration, self-testing, and self-supervision occurs. The unstructured presentation of her opinions about the chosen steps indicates that this feminine female student is not yet able to communicate ideas abstractly. She is also not yet able to evaluate what she has written in her plan.

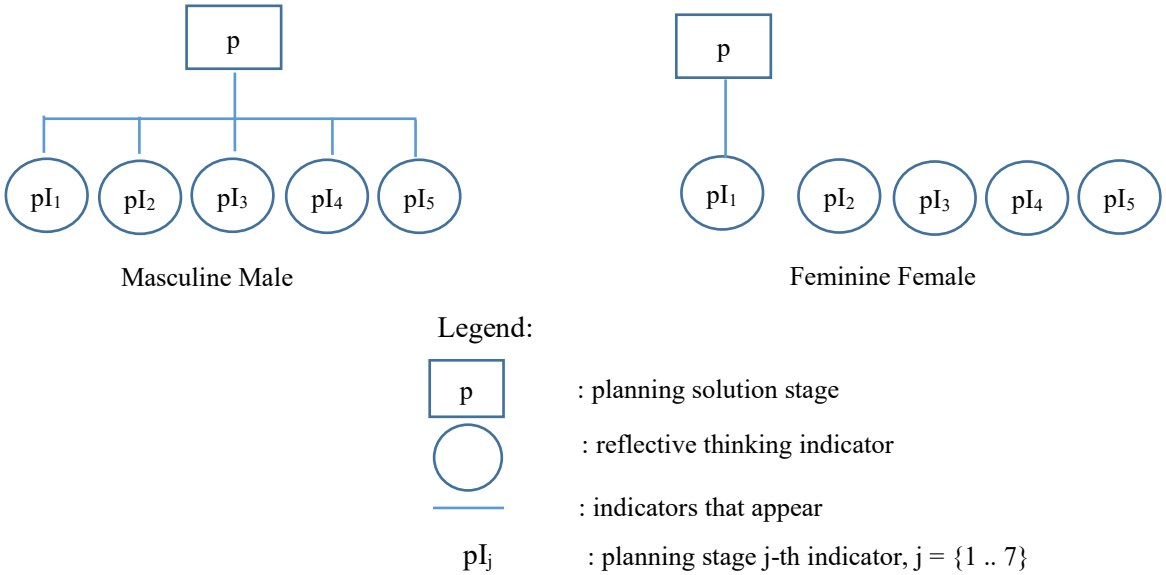


Figure 3. Differences in Reflective Thinking at the Solution Planning Stage

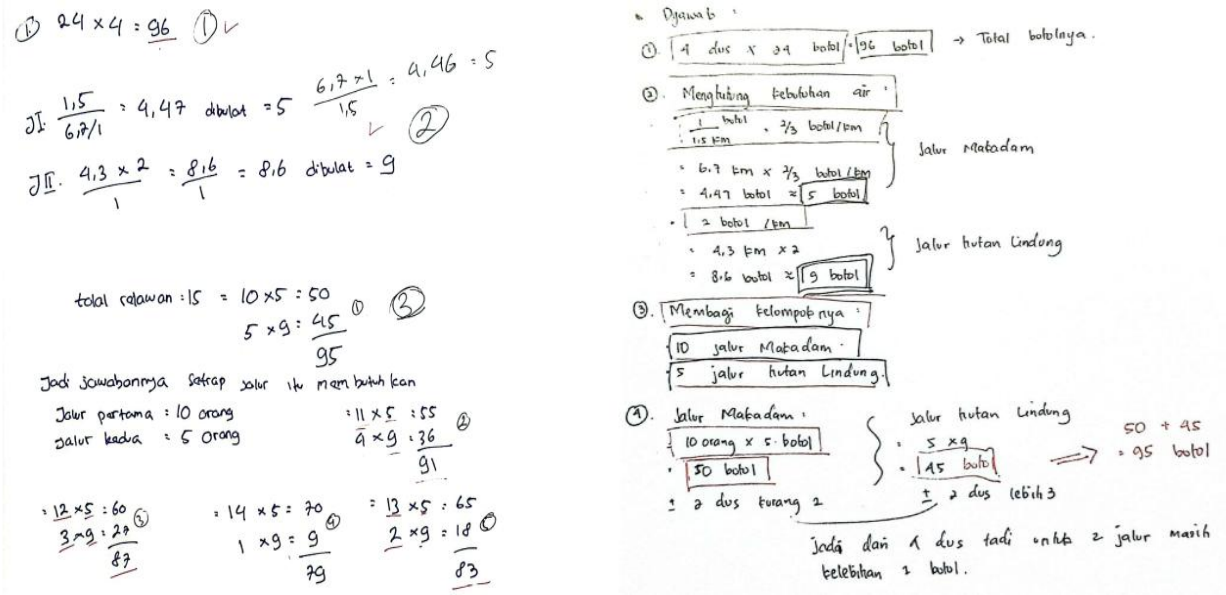
A masculine male student can fully articulate the steps for planning a solution. Each step required to complete the PST is outlined in detail, leaving nothing out. He carefully considers each step during this process. This aligns with Soto-González et al (2023) and Bright Asare (2025), who argues that reflective thinking requires a person to carefully reconsider previous information and established beliefs. He plans with discipline and thoroughness (Kasalak et al, 2022) and is detailed and meticulous. Meanwhile, a feminine female student cannot fully articulate the steps for planning a solution. The steps required to complete the PST are not fully articulated, so doing so may not completely solve the problem. Although this process is a deliberate thought process, he is rushed, lacking in depth consideration of the cyclical nature of the chosen steps and should be revisited (Farahian et al., 2021).

Masculine male students are able to provide logical reasons that if the planning steps are carried out, the problem will be resolved. The ability to provide logical reasons indicates that he made considerations before providing reasons, was able to find the right reasons or criteria (Sanchez-Martí et al., 2018). This also means that the masculine male student is able to review the previous process (Orakcı, 2021) to find the right reasons. Meanwhile, feminine female students are unable to provide logical reasons that if the planning steps are carried out, the problem will be resolved. This indicates that she has not been able to identify the strengths and weaknesses of previous information (Hikmahfadlia & Utami, 2025), and has not even been able to identify aspects that need improvement (Harvey et al, 2025). The inability to provide logical reasons indicates that she is not yet able to make considerations, is not able to find the right reasons or criteria (Sanchez-Martí et al., 2018).

Masculine male students in planning solutions are characterized by their ability to convey planning steps systematically. The sequence of these planning steps is conveyed logically. A step cannot be carried out if the previous step has not been implemented. This shows that during the reflective thinking process, a person thinks in a disciplined, thorough, and systematic manner (Göğüş et al., 2020). In addition to being systematic, during the reflective thinking process he thinks analytically, realizing that there are cyclical and recursive elements (Mohamed et al, 2022) because the planning stages are arranged sequentially and interrelated. Meanwhile, feminine female students are unable to convey planning steps systematically. The plan presented is jumpy, unstructured, and lacks a logical sequence so that she cannot be sure whether the steps in this plan can complete all the desired PST. This indicates that the reflective thinking process is not yet deep enough so that he cannot understand the relationship between previous information and subsequent information (Morkoyunlu & Altun, 2022).

Implementing the Plan Stage

During the planning implementation stage, the reflective thinking processes of masculine male students differed from those of feminine female students. The masculine male student presented and wrote down complete alternative solutions. He also provided logical justifications that the steps taken and the resulting solutions were sufficient to solve the given problem. Meanwhile, the feminine female student presented and wrote down incomplete alternative solutions. She also provided illogical justifications that the steps taken to find the solution were sufficient to solve the problem. Examples of the subject's work results are presented in Figure 4.



Masculine Male Feminine Female

Figure 4. Examples of Subject Work Result

Masculine male students can convey and write complete answers or alternative solutions to the PST. Because the PST is an open-ended problem, it is possible that there is more than one alternative solution. Similarly, there may be more than one solution. Masculine male students who write complete alternative

answers demonstrate discipline and thoroughness. This process also involves elements of inquiry (Kasalak et al, 2022) because once one alternative is found, others are tried until all possible alternatives are found. He thinks carefully, thoroughly, and systematically (Göğüş et al., 2020). Meanwhile, feminine female students convey and write incomplete answers or alternative solutions to the PST. Not all alternative solutions that should be available can be conveyed. Because of the element of trial and error, she does not attempt to try all possible alternatives. When this feminine female student finds a possible alternative, she does not carefully reconsider previous information and other alternative answers. Although this process is a deliberate thinking activity, he is less aware that there is a cyclical element, so he does not carry out the activity of checking and rechecking the alternative solutions produced as suggested by Farahian et al (2021).

Masculine male students can provide logical reasons that the steps in the work and the resulting solutions have been able to solve the given problem. This ability to provide logical reasons shows that during reflective thinking he is able to analyze why the alternative answers were chosen and is able to communicate the ideas created (Chamdani et al., 2022). This is in line with the opinion of Al-Rashidi & Aberash (2024) and Asare (2025) that reflective thinking is used to analyze and decide what has been done or what is believed. Meanwhile, feminine female students cannot provide logical reasons that the alternative solutions found have been able to solve the given PST. The alternative solutions found are not all presented according to what is required in the PST. This shows that the person concerned has not been able to identify the strengths and weaknesses of the existing information (Hikmahfadlia & Utami, 2025) and has not been able to identify parts that need improvement (Harvey et al, 2025). This inability to provide logical reasons also indicates that the feminine female student during reflective thinking has not been able to question different ideas, predict results and evaluate the strategies that have been made (Azimi et al., 2023).

Recheck Stage

In the rechecking stage, the reflective thinking process of masculine male students differs from that of feminine female students. Masculine male students recheck the complete alternative solutions obtained. Meanwhile, feminine female students recheck the incomplete alternative solutions obtained. Furthermore, masculine male students try to find other different strategies to solve the given problem. In addition to using trial and error, these masculine male students also try using algebraic methods, namely by creating mathematical models using equations and inequalities. Although ultimately, this second strategy does not completely produce the expected alternative solutions. Meanwhile, feminine female students do not have other strategies to solve the problem. They only use trial and error to generate alternative solutions to the given PST. The difference in reflective thinking at the re-checking stage can be seen in Figure 5.

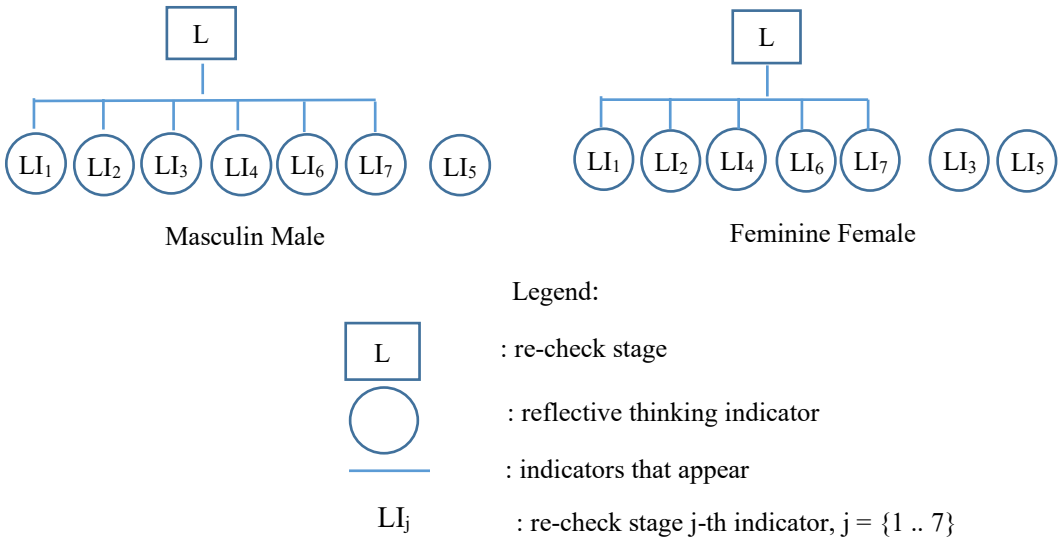


Figure 5. Differences in reflective thinking at the re-checking stage

The masculine male student thoroughly reviewed the alternative answers. He rechecked all the alternative answers presented and determined that they were indeed the correct answers according to the given PST. This means that during the reflective thinking process, the masculine male student carefully reconsidered all

alternative answers and carefully considered the confidence in the chosen alternative (Soto-González et al, 2023; Asare, 2025). He used trial and error to find alternative solutions and choose which alternative was the answer according to the given PST. This thinking activity indicates that he thought in detail and carefully and full of awareness (Abualrob, 2025). Meanwhile, the feminine female student incompletely reviewed the alternative answers. All alternative answers should have been found even through trial and error. This student was hastily satisfied with only a few answers. This also indicates that he thought carelessly, was less thorough, and did not realize that there was an element of inquiry in finding all alternative answers (Kasalak et al, 2022). When he rechecked all the alternative answers, he should have done it patiently because the reflective thinking process requires sufficient time (Farahian et al., 2021).

The masculine male student attempted to find a different strategy to solve the given problem. He tried using algebra, namely by creating a mathematical model using equations and inequalities. However, this strategy ultimately failed and did not find the expected solution. He felt confused about solving the equations and inequalities he created. This shows that he carried out critical reflection (Kaloudis et al., 2025) on the previous strategy by rethinking and re-evaluating the strategy used. When rethinking the chosen strategy, a person will question the chosen method and choose the method that is considered correct (Li, 2025). Meanwhile, the feminine female student tried to think of another strategy but did not find one. She had tried but was unsuccessful. This shows that during the reflective thinking process, a person has the opportunity to re-examine and find the best way to achieve goals (Chu et al, 2023).

The differences in the reflective thinking profiles of masculine male prospective teacher students and feminine female prospective teacher students in solving open-ended mathematics problems are shown in Table 2.

Table 2. Differences in the reflective thinking profiles of masculine male and feminine female prospective teacher students in solving open-ended mathematics problems

No	Stage	Masculine Male	Feminine Female
1	Understanding the problem	Re-conveying what is understood in an unstructured manner	Re-conveying what is understood in a structured manner
2	Planning solutions	can mention the steps to plan a solution correctly	unable to correctly state the steps to plan a solution
		can mention the steps for planning a complete solution	cannot mention the steps to plan a complete solution
		Reasons explicitly articulated	Reasons not explicitly articulated
		planning steps fully justified	planning steps not fully justified
3	Executing the Plan	convey and write down complete alternative solutions	convey and write down alternative solutions incompletely
		provide logical reasons that the steps taken to find a solution can solve the problem	giving illogical reasons that the steps taken to find a solution can solve the problem
4	Re-checking	re-check the alternative solutions obtained completely	re-check the alternative solutions obtained incompletely
		have other strategies, but they are not complete	have no other strategy

Table 2 shows that masculine male students conveyed what they understood randomly, while feminine female students conveyed it sequentially. This indicates that at the beginning, feminine female students had better mindfulness than male students (Abualrob, 2025). The ability of masculine male students to correctly and completely state the steps for planning a solution indicates that they can bridge the gap between what is known and what is desired (Tuononen et al, 2023). Female students were unable to provide logical reasons and carried out the steps unsystematically, indicating that they were not yet able to modify their understanding (Merkebu et al, 2024). When implementing the plan, masculine male students conveyed complete alternative solutions accompanied by logical reasons. This supports the opinion of Azimi et. al. (2023). Meanwhile, feminine female students conveyed and wrote down alternative solutions incompletely and were unable to provide logical reasons. During the review, masculine male students reviewed the complete alternative solutions and identified alternative strategies. Meanwhile, feminine female students reviewed the incomplete alternative solutions and identified alternative strategies. It appears that masculine male students performed

better in reflective thinking than feminine female students. This positively impacted their problem-solving abilities (Asare, 2025).

This study's limitations lie in the gender categories used. The selected subjects were limited to male students with masculine tendencies and female students with feminine tendencies. The results of the study cannot yet describe the reflective thinking process in individuals with androgynous or undifferentiated gender types. Therefore, the findings of differences in reflective thinking in solving open-ended problems are specific to these gender characteristics and are not intended to generalize to the entire student population based solely on biological sex. Furthermore, the study's limitations lie in the open-ended nature of the problem-solving task instrument. The use of open-ended problems aims to stimulate in-depth reflective thinking processes. The results may show different patterns if applied to closed-ended or routine mathematical problems.

The results of this study make a significant contribution to achieving the SDGs, particularly in terms of quality education, particularly in ensuring an effective learning process for prospective educators. By uncovering differences in reflective thinking between masculine male and feminine female students in solving mathematical problems, educational institutions that produce prospective teachers can design more precise didactic interventions. Strengthening reflective thinking, especially for students who still exhibit cognitive barriers, is key to improving the quality of prospective teachers. In the context of gender equality, these findings offer important insights into bridging the qualitative gap in reflective thinking skills. Differences between male and female students should not be used to legitimize gender stereotypes, but rather as a basis for developing gender-responsive educational policies.

CONCLUSION

From these numerous differences, it can be concluded that gender differences qualitatively influence a person's reflective thinking in solving open-ended mathematics problems. In this exploratory case study, the masculine male participant demonstrated more systematic reflective patterns than feminine female students during the reflective thinking process. This finding has important implications for educators in designing more adaptive and gender-responsive mathematics learning strategies to optimize students' reflective thinking abilities, especially in groups that require more intensive intervention. When planning solutions, feminine female students' reflective thinking processes are less in-depth, resulting in unsystematic planning steps. Therefore, further research is needed on how to improve feminine female students' reflective thinking, especially in providing logical reasons and the ability to express ideas well.

AUTHOR CONTRIBUTIONS

Zainal Abidin: Conceptualization, Methodology, Formal Analysis, Project Administration, Writing – Original Draft; **I Ketut Budayasa**: Conceptualization, Methodology, Visualization and Validation; and **Siti Khabibah**: Validation, Data Curation. All authors have read and approved the final version of this manuscript.

DATA AVAILABILITY STATEMENT

The data supporting the findings of this study are available from the authors upon reasonable request, subject to ethical approval and institutional regulations.

DECLARATION OF COMPETING INTEREST

The authors declare no known financial conflicts of interest or personal relationships that could have influenced the work reported in this manuscript.

DECLARATION OF ETHICS

The authors declare that the research and writing of this manuscript adhere to ethical standards of research and publication, in accordance with scientific principles, and are free from plagiarism.

DECLARATION OF ASSISTIVE TECHNOLOGIES IN THE WRITING PROCESS

The authors declare that generative artificial intelligence (Gen AI) and other AI-assisted tools were used prudently, not excessively, during the research and preparation of this manuscript. Specifically, ChatGPT was used for brainstorming ideas; Grammarly for grammar and style correction; and Scite for analysing citation contexts. All AI-generated material was reviewed and edited for accuracy, completeness, and compliance with ethical and scholarly standards. The authors accept full responsibility for the final content of the manuscript.

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