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GEOMETRIC THINKING OF JUNIOR HIGH SCHOOL STUDENTS IN SOLVING SIMILARITY PROBLEMS BASED ON GENDER DIFFERENCES

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ABSTRACT
This study aims to describe students' geometric thinking processes in solving similarity problems based on gender differences using Polya's problem-solving stages. This study was motivated by students' difficulties in understanding geometric concepts and the lack of in-depth analysis of thinking processes in previous studies. A qualitative descriptive approach was employed with two ninth-grade students (one male and one female) selected purposively based on equivalent mathematical ability. Data were collected through Geometry Problem-Solving Tasks (GPST) and semi-structured interviews. Data were analyzed through reduction, display, and conclusion drawing, supported by triangulation techniques. The results indicate that female students demonstrate more systematic and reflective thinking, while male students show more flexible and intuitive strategies. These findings highlight that gender differences influence cognitive processes rather than final outcomes. The study contributes to a deeper understanding of students' geometric thinking using Polya's framework.
Keywords: *construction; gender differences*; *geometric thinking.*

ABSTRAK
Penelitian ini bertujuan untuk mendeskripsikan proses berpikir geometris siswa dalam menyelesaikan masalah kesamaan berdasarkan perbedaan gender menggunakan tahapan pemecahan masalah Polya. Pendekatan deskriptif kualitatif digunakan. Subjek penelitian adalah dua siswa SMP dengan kemampuan matematika yang setara. Data dikumpulkan melalui tugas pemecahan masalah dan wawancara semi-terstruktur. Data dianalisis menggunakan reduksi, tampilan, dan penarikan kesimpulan. Hasil penelitian menunjukkan bahwa siswa perempuan cenderung lebih sistematis dan reflektif, sedangkan siswa laki-laki cenderung lebih fleksibel tetapi kurang terstruktur. Namun, keduanya mencapai solusi yang benar. Temuan ini menunjukkan bahwa perbedaan gender memengaruhi proses kognitif daripada hasil belajar.
Kata kunci*: konstruksi; pemikiran geometris; perbedaan gender.*

Introduction

Geometry is one of the fundamental branches of mathematics that plays a crucial role in the educational curriculum, particularly at the junior secondary school level (Ubi & Odiong, 2018) (Luthfi & Jupri, 2020). This field of study examines the relationships among spatial elements such as points, lines, angles, planes, two-dimensional shapes, and three-dimensional objects (Aini & Manoy, 2026). Understanding these concepts is not only essential in an academic context but also plays a significant role in enabling students to interpret phenomena in their surrounding environment. Therefore, geometry serves as an important foundation for developing higher-order mathematical thinking skills. Moreover, mastery of geometry supports students' ability to solve various contextual problems encountered in everyday life.

Students' ability to solve geometric problems is closely related to differences in their cognitive strategies. Krutetskii's theory of mathematical abilities has been widely adopted in recent studies; for instance, Bakker et al. (2022) explain that students employ different problem-solving strategies depending on their cognitive characteristics, including strategy variation, cognitive flexibility, and spatial visualization abilities. In the context of learning, the PBL model can be applied to students effectively (Darojah et al., 2025). These differences are reflected in the speed of information processing as well as in the use of visual representations. (Helpern, 2000) further emphasizes that males tend to excel in visual-spatial abilities, whereas females are generally stronger in verbal skills and accuracy. These differences have implications for how students understand, organize, and solve geometric problems (Sari et al., 2020)(Purwasih et al., 2019). The problem in mathematics is the lack of student interest in understanding mathematical concepts and the importance of utilizing technology (Arif et al., 2026).

Geometry learning provides various benefits in developing students' overall competencies. (Walle, 2003) states that geometry not only helps students understand mathematical concepts but also fosters an appreciation of the environment and enhances problem-solving abilities. In addition, geometry plays a significant role in supporting other areas of mathematics and has wide applications in daily life. Therefore, geometry instruction needs to be designed optimally to provide meaningful learning experiences. The development of geometric thinking is influenced not only by students' cognitive abilities but also by the learning environment. (Battista et al., 2017) asserts that students' understanding of geometric concepts becomes deeper when they are actively engaged in exploration and manipulation of geometric objects. Such active involvement enables students to construct strong mental representations, making constructive and interactive learning approaches essential.

Geometric thinking is defined as a mental process that involves understanding shapes, spatial relationships, and solving problems related to geometric objects (Tarlina et al., 2024). This process includes activities such as observing, analyzing, comparing, and drawing conclusions about geometric objects. Thus, geometric thinking focuses not only on final answers but also on the processes students undergo in constructing understanding. This ability is fundamental to meaningful mathematics learning. In the context of the Merdeka Curriculum, geometric thinking plays a strategic role as it is closely related to the development of higher-order thinking skills (HOTS). (Purnamatati et al., 2024) highlights that geometric thinking contributes to the development of spatial skills, visualization, and deductive reasoning, which are essential for advanced mathematical topics such as trigonometry and calculus. Therefore, strengthening geometric thinking is a key necessity in modern mathematics education.

Furthermore, geometric thinking contributes to the development of students' critical, systematic, and logical attitudes in problem solving. (Locatelli & Arroio, 2013) emphasize that this ability not only affects academic success but also prepares students to face real-life challenges. However, research on geometric thinking still shows certain limitations. (Wahyuni et al., 2025) reveals that most studies tend to focus on the van Hiele theory and rarely examine geometric thinking as a comprehensive problem-solving process. This indicates the need for more in-depth studies that explore students' geometric thinking processes more holistically.

Thinking and problem solving are closely interconnected activities. (Maclin, 2014) explain that thinking is essentially a process of solving problems, while (Walle, 2003) identifies problem solving as a central component of mathematics learning. Therefore, geometric thinking can be examined through the processes students use when solving geometric problems. Students' problem-solving abilities are influenced by their prior knowledge and experiences. (Juniati & Siswono, 2017) state that prior experience helps students determine appropriate strategies. However, (Klang et al., 2021) found that students often struggle to identify relevant information and visualize appropriate solutions, indicating that their geometric thinking abilities still require further development.

Preliminary observations at SMP IT Insan Kamil reveal that students experience difficulties in solving geometric problems, particularly in visualization, construction, and reasoning, as proposed by (Duval, 2011). To overcome difficulties in solving real-life problems, practice problems that contain everyday contexts are necessary (Sugiharti et al, 2025). Students tend to recognize shapes visually but struggle to construct solutions and provide logical justifications. This condition indicates that students' geometric thinking processes have not yet developed optimally. Additionally, their problem-solving processes are often procedural and lack integration between visualization, construction, and reasoning, which leads to difficulties in solving non-routine problems. Therefore, a deeper investigation into students' geometric thinking processes is necessary.

Gender differences are considered one of the factors influencing students' geometric thinking processes. (Hyde, 2005) suggests that differences in mathematical ability between males and females are relatively small but may appear in specific contexts. This implies that differences are more evident in strategies and thinking processes rather than in final outcomes. In geometry learning, (Helpern, 2000) show that males tend to excel in spatial visualization, while females demonstrate greater accuracy and systematic approaches. These differences influence how students construct representations and develop problem-solving strategies.

From a problem-solving perspective, Pólya (1973) proposes four main stages: understanding the problem, devising a plan, carrying out the plan, and looking back. Gender differences may emerge at each of these stages, both in strategies and approaches used by students. Therefore, analyzing students' thinking processes based on Pólya's stages is essential in understanding geometric thinking. In this study, geometric thinking is conceptualized as a cognitive process

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that bridges conceptual understanding and problem-solving ability. It is not limited to recognizing shapes but involves complex mental processes in processing visual and symbolic information. (Yudianto et al., 2021) and (Prayito et al., 2018) argue that geometric thinking develops progressively through different levels, reflecting improvements in students' understanding. Thus, the analysis focuses on processes rather than outcomes.

To strengthen the analytical framework, geometric thinking is viewed as involving mental representations of geometric objects. (Battista et al., 2017) explains that this process includes constructing, modifying, and interpreting spatial representations. This perspective aligns with earlier findings indicating students' difficulties in visualization, positioning visualization as a critical initial component of geometric thinking. The development of geometric thinking is also influenced by cognitive stages. Geometric understanding develops progressively through stages of cognitive growth. Recent studies (Wilke et al., 2024) indicate that students' understanding of geometry evolves from concrete experiences toward more abstract reasoning through the use of representations and structured thinking. This progression explains why junior secondary students often experience difficulties when dealing with non-routine problems, as they are still transitioning from concrete visualization to abstract reasoning.Furthermore, (Deal & Wismer, 2000) emphasizes that geometry learning should develop students' ability to explain and justify relationships, reinforcing the importance of reasoning in geometric thinking.

This study adopts Duval's theoretical framework, which identifies three components of geometric thinking: visualization, construction, and reasoning (Puloo et al., 2018). These components are directly related to the difficulties identified earlier. Visualization involves forming mental images, while (Duval, 2011) emphasizes that it includes interpreting and transforming representations. Construction refers to building geometric objects mentally or physically and reasoning involves constructing logical arguments (Jones et al., 2012). Together, these components provide a comprehensive basis for analyzing students' thinking processes. To further analyze students' thinking processes, this study employs Pólya's (1973) problem-solving stages. (Rosyidi et al., 2020) notes that problem solving serves as a means to reveal students' thinking processes. Therefore, combining Duval's framework with Pólya's stages allows for a more comprehensive analysis of geometric thinking.

Representation also plays a crucial role in understanding geometry. (Duval, 2011) emphasizes that geometric understanding depends on coordinating multiple representations. This supports earlier findings regarding students' difficulties in interpreting information. Additionally, gender is considered an important variable influencing students' thinking processes. (Helpern, 2000) and (Hyde, 2005) suggest that gender differences are more evident in cognitive strategies than in final outcomes. Studies on gender differences in mathematical thinking have consistently highlighted variations in cognitive strategies. Early work by Fennema and Sherman (1977), as cited in recent studies (Wilke et al., 2024), indicates that male and female students may differ in their approaches to mathematical tasks, particularly in spatial strategies and confidence in problem solving. This finding is further supported by (Voyer & Voyer, 2014), who show that differences in spatial

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abilities can influence how students process and solve geometric problems. In the context of geometry learning, (Yanuar et al., 2022) provide empirical evidence that gender differences are reflected in students' levels of geometric thinking, where variations appear in how students analyze shapes, construct solutions, and justify their answers. These findings indicate that gender not only influences cognitive tendencies but also affects the depth and structure of students' geometric reasoning processes.

Despite the growing body of research on geometric thinking and problem solving, several gaps remain in the literature. Previous studies have primarily focused on geometric thinking using specific theoretical frameworks such as van Hiele levels or representation theory, while others have examined gender differences in mathematical performance. However, limited studies have explicitly integrated Pólya's problem-solving stages with geometric thinking components, particularly visualization, construction, and reasoning, in the context of similarity topics at the junior secondary level. Furthermore, existing research often emphasizes learning outcomes rather than examining the underlying thinking processes in depth.

Therefore, this study aims to fill this gap by providing a comprehensive analysis of students' geometric thinking processes through the integration of Pólya's problem-solving stages and geometric thinking components, viewed from a gender perspective. This study contributes theoretically by offering a more holistic framework for analyzing students' thinking processes, and practically by providing insights for designing more inclusive and process-oriented geometry instruction.

Research Methods

This study employed a qualitative descriptive approach to explore in depth students' geometric thinking processes in solving geometry problems. The qualitative design was considered appropriate because it allows the researcher to examine not only the final answers produced by students but also the underlying cognitive processes involved during problem solving. In particular, this study focused on how students engage in visualization, construction, and reasoning when dealing with geometry tasks. The research was conducted at SMP IT Insan Kamil, involving students from one class as the initial participants. This setting was selected because it provided access to students with relatively homogeneous learning experiences, allowing the researcher to focus more specifically on differences in thinking processes rather than differences in instructional background. This approach is consistent with qualitative research that emphasizes depth of understanding over generalization.

The participants in this study were determined through a purposive sampling technique. Initially, all students in the selected class were involved in the first stage of data collection through a geometry test. The purpose of this initial test was to identify students' levels of mathematical ability, particularly in geometry, and to determine potential subjects for further in-depth analysis. Based on the results of the initial test, two students with the highest scores were selected as the main research subjects. These students were chosen because they demonstrated strong mathematical abilities, which allowed the researcher to explore their thinking processes more deeply and clearly. Focusing on high-achieving students also enabled the identification of complete and structured problem-solving processes. The selection criteria also considered students' ability to communicate their thinking clearly and their willingness to participate in interviews, ensuring the richness of the data obtained.

The selection of only two subjects was intentional and aligned with the qualitative nature of the study, which prioritizes depth of analysis over the number of participants. By focusing on a small number of subjects, the researcher was able to conduct a more detailed and intensive examination of each student's geometric thinking process. Although the number of subjects is limited, this is consistent with a case study approach, where the goal is not to generalize findings but to gain an in-depth understanding of a particular phenomenon. Data collection in this study was carried out in two main stages. The first stage involved administering a geometry test to all students in the class. This test served as an initial screening tool to identify students' abilities and to select the research subjects based on their performance. The second stage of data collection involved administering a follow-up test to the selected subjects. This test consisted of non-routine geometry problems designed to elicit deeper thinking processes. The problems required students to interpret information, develop strategies, and provide logical reasoning in solving the tasks. An example of the task includes determining the area of a composite geometric figure consisting of a trapezoid, square, and semicircle, requiring the integration of multiple geometric concepts.

In addition to the written tests, semi-structured interviews were conducted with the selected students. These interviews aimed to explore students' reasoning in greater detail, clarify their written responses, and uncover the cognitive processes that might not be visible from their written work alone. The interview process was flexible, allowing the researcher to ask follow-up questions based on students' responses. Each interview lasted approximately 20–30 minutes and involved open-ended questions designed to probe students' understanding, strategies, and reasoning. Probing techniques were used to clarify responses and to reveal deeper cognitive processes. This approach enabled the researcher to gain richer and more comprehensive data regarding how students think, particularly in terms of visualization, construction, and reasoning.

The data analysis in this study was guided by the problem-solving stages proposed by Pólya (1973), which include understanding the problem, devising a plan, carrying out the plan, and looking back. These stages were used to analyze how students approached and solved the given geometry problems systematically. In addition to Pólya's stages, the analysis also employed Duval's theoretical framework, which focuses on three components of geometric thinking: visualization, construction, and reasoning. Visualization refers to students' ability to form and interpret geometric representations, construction involves the ability to create and manipulate these representations, and reasoning relates to the ability to justify and explain solutions logically. The integration of Pólya's stages and Duval's framework provided a comprehensive analytical approach. Each student's responses were analyzed by mapping their problem-solving steps to Pólya's stages while simultaneously identifying the presence of visualization, construction, and reasoning within each stage. Data analysis followed the steps of data reduction, data display, and conclusion drawing. To enhance analytical rigor, coding and

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categorization techniques were applied. Students' written responses and interview transcripts were coded based on indicators of visualization, construction, and reasoning, as well as the stages of problem solving. The coding process involved identifying meaningful data units, grouping them into categories, and interpreting patterns across the data.

The research procedure was carried out in four main stages, namely preparation, implementation, data analysis, and conclusion. In the preparation stage, the researcher designed the research instruments and validated them through expert judgment to ensure their suitability and clarity. Construct validity was ensured by aligning the instruments with the theoretical frameworks of Pólya and Duval. In the implementation stage, the researcher administered the initial test to the entire class, selected the research subjects, and conducted the follow-up test and interviews. This stage was crucial for obtaining both written and verbal data related to students' thinking processes. The data analysis stage involved organizing students' written responses, transcribing interview data, coding the data based on predetermined indicators, and interpreting the results. To ensure the trustworthiness of the findings, triangulation was applied by comparing data from written tests and interviews. Member checking was also conducted to confirm the accuracy of interpretations with the participants. Finally, in the conclusion stage, the researcher synthesized the findings to describe students' geometric thinking processes and to identify patterns that emerged during the study. To minimize researcher bias, the analysis was conducted systematically using predefined categories and by repeatedly reviewing the data to ensure consistency between interpretations and actual findings. The research process was documented thoroughly to maintain dependability and confirmability.

Results and Discussion

The results of this study describe in detail the geometric thinking processes of students in solving geometry problems based on gender differences. The data were obtained from written responses to Geometry Problem-Solving Tasks (TPMG) and supported by semi-structured interviews, allowing the identification of students' thinking processes across the stages of problem solving proposed by Pólya, namely understanding the problem, devising a plan, carrying out the plan, and looking back. The analysis focused on two selected subjects, namely a male student (RPM) and a female student (HAR), both of whom were categorized as high-achieving students based on the results of the initial test. These students were chosen to represent clear and complete thinking processes, enabling a deeper exploration of how geometric thinking manifests during problem solving.

The geometry problem-solving task (TPMG) used in this study was designed to assess students' geometric thinking processes, particularly in visualization, construction, and reasoning. The task required students to solve a non-routine problem involving similarity and area relationships. An example of the task is presented in Figure 1.

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SOAL TUGAS PEMECAHAN MASALAH GEOMETRI

1. Tanah milik Pak Isman berbentuk trapesium sama kaki dengan panjang sisi sejajar adalah 18-meter dan 30 meter, serta memiliki tinggi 12 meter.
   Pada tanah tersebut akan dibangun taman bunga yang terdiri dari sebuah taman berbentuk persegi dan sebuah taman berbentuk lingkaran. Kedua taman bunga diletakkan berdampingan di bagian tengah tanah dan tidak saling tumpang tindih. Seluruh bagian tanah di luar taman bunga akan ditanami rumput.
   Pak Isman merencanakan membeli rumput dengan luas kurang dari 150 m^2.
   Dengan menggunakan $\pi = 22/7$, tentukan ukuran taman bunga yang mungkin (panjang sisi persegi dan jari-jari lingkaran) beserta posisi penempatannya pada tanah Pak Isman agar luas rumput yang dibutuhkan memenuhi rencana tersebut!

Figure 1. Geometry Problem-Solving Task (TPMG)

At the stage of understanding the problem, both students demonstrated the ability to identify relevant information presented in the problem. They were able to determine known and unknown elements, including geometric shapes, measurements, and relationships between figures, indicating an adequate level of initial comprehension. The male student showed an understanding of the problem by directly identifying key information and mentally organizing it without explicitly writing all details. His responses indicated that he was able to grasp the essential aspects of the problem efficiently, although not all components of his understanding were documented in written form.

In contrast, the female student demonstrated a more explicit and systematic approach in understanding the problem. She wrote down known and unknown information in detail, organized the given data clearly, and ensured that all elements of the problem were properly identified before proceeding to the next stage. Both students also engaged in rereading the problem to confirm their understanding. This behavior indicates the presence of reflective thinking even at the initial stage, as they attempted to avoid misinterpretation of the problem statement. In terms of visualization, both students were able to interpret geometric representations and mentally construct images of the given problems. They recognized shapes such as trapezoids, squares, and circles and understood their relationships within the problem context.

However, differences emerged in how visualization was externalized. The male student tended to rely on internal visualization and did not always produce sketches or diagrams, whereas the female student frequently used drawings to support her understanding and clarify relationships between geometric elements. At the stage of devising a plan, both students were able to determine appropriate strategies for solving the problem. They identified relevant geometric concepts and formulas, including area calculations for different shapes, and used these concepts as the basis for their solution strategies. The male student demonstrated a flexible approach in planning, often moving directly from understanding the problem to applying formulas. His planning process was not always explicitly written, but it was evident from his ability to proceed correctly to the execution stage.

On the other hand, the female student showed a more structured planning process by outlining steps before executing them. She explicitly described the sequence of actions to be taken, including identifying formulas and organizing the solution path in a logical order. Both students used representations in the form of

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sketches during the planning stage, although the level of detail differed. The female student's sketches were more organized and labeled, while the male student's representations were simpler and sometimes implicit. At the stage of carrying out the plan, both students successfully applied the selected strategies to solve the problems. They performed calculations accurately and followed appropriate procedures in determining the required values.

The male student demonstrated efficiency in executing the solution, often completing calculations quickly and correctly. His work indicated a strong understanding of geometric formulas and their application, even though intermediate steps were not always fully written. The female student, in contrast, carried out the plan in a more detailed and systematic manner. She showed each step of the calculation process clearly, ensuring that all procedures were documented and logically connected. In terms of reasoning, both students were able to justify their answers, but differences were observed in the clarity and structure of their explanations. The female student provided more coherent and comprehensive reasoning, while the male student's explanations were shorter and less explicitly structured.

At the stage of looking back, both students demonstrated the ability to verify their answers. They rechecked their calculations and ensured that the results were consistent with the problem requirements. The male student tended to perform this verification process mentally without writing it down, indicating an internal reflective process. In contrast, the female student explicitly wrote down the checking process, showing a more observable form of reflection. Overall, both students were able to complete all stages of Pólya's problem-solving process successfully. However, the way these stages were expressed differed, particularly in terms of explicitness, organization, and representation of thinking processes. The results indicate that while both male and female students achieved correct solutions, differences were evident in their geometric thinking processes. These differences were particularly noticeable in visualization, planning, reasoning, and reflection, suggesting that gender influences how students organize and express their thinking during problem solving.

The findings of this study reveal that students' geometric thinking processes cannot be fully understood by examining final answers alone, but must be analyzed through the stages of problem solving. The use of Pólya's framework provides a structured lens to observe how students interpret, plan, execute, and reflect on geometry problems, while also uncovering differences in cognitive processes that are not immediately visible in written work. At the stage of understanding the problem, both students demonstrated the ability to identify relevant information presented in the problem. They were able to determine known and unknown elements, including geometric shapes, measurements, and relationships between figures, indicating an adequate level of initial comprehension. Based on the TPMG results, the male student (RPM) was able to identify important elements of the problem, such as the trapezoid with parallel sides of 18 meters and 30 meters and a height of 12 meters, as well as the presence of a square and a circle within the figure. However, this identification was not fully written in a structured form. This is supported by the interview results, where RPM stated:

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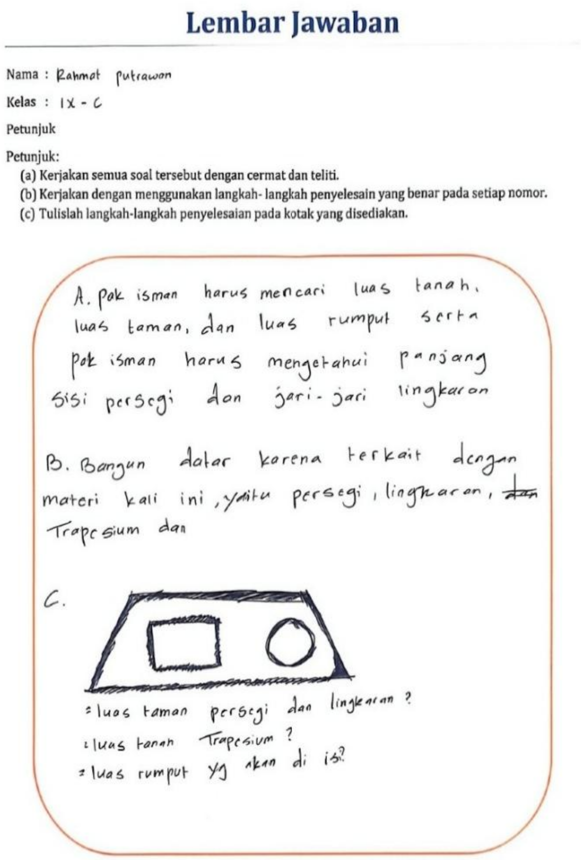
"Supaya benar-benar paham apa yang diketahui dan yang ditanyakan, Bu."
He also mentioned:
"Tiga kali, Bu."
It indicatie that he reread the problem multiple times to ensure understanding. Furthermore, RPM explained the main problem as:
"Menentukan ukuran taman persegi dan taman lingkaran supaya luas rumputnya kurang dari 150-meter persegi."
This shows that the student was able to grasp the core objective of the problem, although much of the process occurred internally.

In contrast, the female student (HAR) demonstrated a more explicit and systematic approach in understanding the problem. She clearly organized the known information and represented the relationships between geometric shapes through sketches. Although RPM relied more on internal visualization, HAR externalized her thinking by drawing a trapezoid and placing the square and circle within it. This difference indicates that while both students achieved comprehension, the female student's process was more observable and structured. At the stage of devising a plan, both students were able to determine appropriate strategies for solving the problem. They identified relevant mathematical concepts such as the area of trapezoids, squares, and circles, and planned to combine these concepts to obtain the final solution is presented in Figure 2.



Lembar Jawaban

Nama : Rahmat putrawan
Kelas : IX - C
Petunjuk

Petunjuk:
(a) Kerjakan semua soal tersebut dengan cermat dan teliti.
(b) Kerjakan dengan menggunakan langkah- langkah penyelesain yang benar pada setiap nomor.
(c) Tulislah langkah-langkah penyelesaian pada kotak yang disediakan.

A. pak isman harus mencari luas tanah, luas taman, dan luas rumput serta pak isman harus mengetahui panjang sisi persegi dan jari-jari lingkaran

B. Bangun datar karena terkait dengan materi kali ini, yaitu persegi, lingkaran, ~~dan~~ Trapesium dan

C.

= luas taman persegi dan lingkaran ?
= luas tanah Trapesium ?
= luas rumput yg akan di isi?

Figure 2. TPMG Result of Male Student

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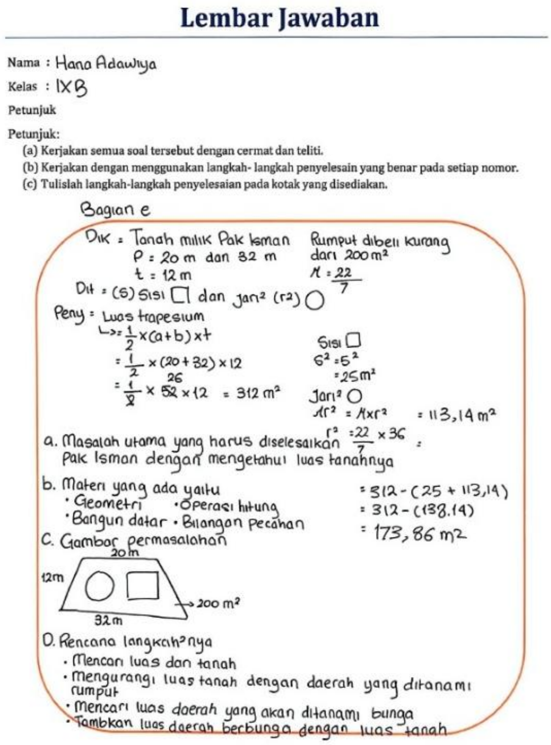

Figure 3. TPMG Result of Female Student

Based on the TPMG results, RPM demonstrated a relatively direct planning process. He stated in the interview:

“Menghitung luas tanah, menentukan luas rumput, lalu mencari ukuran taman.”

This indicates that he used a straightforward strategy by first calculating the total area and then subtracting the areas of the square and circular gardens. Although his planning was effective, it was not always explicitly written in detail. RPM also mentioned:

“Iya, Bu, jadi lebih terarah.”

It shows that the plan helped guide his problem-solving process.

Meanwhile, HAR showed a more structured and detailed planning process. She explicitly described her steps before executing them, including drawing the geometric shapes and identifying their positions. She explained:

“Saya menggambar trapesium dulu, lalu di tengahnya saya gambar persegi dan lingkaran berdampingan.”

She further justified her approach by stating:

“*Supaya lebih jelas letak taman persegi dan lingkarannya dan tahu bagian mana yang ditanami rumput.”*

In addition, HAR outlined her strategy clearly:

“Saya rencananya menghitung luas tanah seluruhnya dulu, lalu mengurangi luas taman persegi dan taman lingkaran.”

This indicates that HAR’s planning was not only systematic but also supported by clear visual representation, making her thinking process more explicit compared to RPM.

At the stage of carrying out the plan, both students were able to implement their strategies and apply appropriate geometric concepts to solve the problem. They performed calculations involving the area of trapezoids, squares, and circles

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accurately, indicating a good understanding of the formulas and procedures required. Based on the TPMG results, the male student (RPM) demonstrated efficiency in executing the solution. He directly applied the formulas and obtained the correct results, although some intermediate steps were not fully written. This suggests that RPM relied on mental calculations and internal reasoning during the execution process. This is supported by his explanation during the interview:
"Menghitung ulang dan memastikan hasilnya tidak lebih dari 150-meter persegi."

This statement indicates that RPM focused on achieving the final result efficiently while ensuring that it met the problem requirements. However, the limited written steps make some parts of his reasoning less visible. In contrast, the female student (HAR) carried out the plan in a more detailed and systematic manner. She showed each step of the calculation clearly, including the process of determining the area of each geometric shape before combining the results. HAR also demonstrated flexibility in trying different values, as she stated:
"Saya mencoba beberapa ukuran sisi persegi dan jari-jari lingkaran, lalu dihitung apakah luas rumputnya sudah kurang dari 200-meter persegi."
This indicates that HAR engaged in an iterative process, testing different possibilities until the conditions of the problem were satisfied. Her approach reflects a more explicit and structured execution process compared to RPM.

In terms of reasoning, both students were able to justify their solutions, although differences were observed in the clarity and completeness of their explanations. RPM provided shorter and more direct justifications, focusing mainly on the correctness of the final result. Meanwhile, HAR demonstrated more comprehensive reasoning by explaining each step and the rationale behind her choices. This suggests that while both students possessed adequate reasoning abilities, HAR's reasoning was more explicitly articulated and easier to follow. At the stage of looking back, both students demonstrated the ability to verify their answers and reflect on the correctness of their solutions. This stage is crucial in ensuring that the results obtained are consistent with the problem requirements.

Based on the interview results, RPM indicated that he checked his answer by recalculating the results and ensuring that they met the given conditions. He stated:
"Menghitung ulang dan memastikan hasilnya tidak lebih dari 150-meter persegi."
This shows that RPM engaged in a reflective process, although it was mostly done mentally and not fully documented in written form. His approach suggests an internal verification process that is efficient but less observable. On the other hand, HAR demonstrated a more explicit form of reflection. She not only rechecked her calculations but also ensured that her solution aligned with the conditions stated in the problem. She explained:
"Saya memastikan lagi apakah hasilnya sudah sesuai dengan ketentuan soal."
This indicates that HAR's reflective process was more systematic and clearly articulated, making her thinking more visible.

Overall, both students were able to complete all stages of Pólya's problem-solving process successfully. However, differences were evident in how these stages were expressed. The male student tended to rely on internal processing, demonstrating efficiency but less explicit representation, while the female student

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showed a more structured and detailed approach, with clear documentation of each step.

The results indicate that while both male and female students achieved correct solutions, their geometric thinking processes differed in terms of visualization, planning, execution, and reflection. These differences were particularly evident in how students externalized their thinking, with the female student showing more explicit representations and the male student relying more on mental processing. Furthermore, the findings reveal that students' geometric thinking processes cannot be fully understood by examining final answers alone. Some aspects of thinking, particularly planning and reflection, were not always visible in written responses but became evident through interviews. This highlights the importance of using multiple data sources in qualitative research.

The combination of TPMG and interview data allowed for a more comprehensive analysis of students' thinking processes. While written responses provided evidence of procedural knowledge and final results, interviews revealed deeper cognitive processes, including how students interpreted problems, selected strategies, and verified their answers. Another important finding is that both students demonstrated strong conceptual understanding, as reflected in their ability to apply appropriate formulas and obtain correct results. However, differences in representation and communication of ideas suggest that geometric thinking is not only about correctness but also about how ideas are organized and expressed.

The results also indicate that visualization plays a significant role in problem solving. Both students were able to mentally construct geometric representations, but differed in how they externalized these representations. The female student's use of diagrams supported her reasoning and made her thinking more transparent, while the male student's reliance on internal visualization made some aspects of his thinking less observable. These findings suggest that differences in geometric thinking are more closely related to cognitive and representational styles rather than differences in ability. Both students demonstrated high levels of competence, but expressed their thinking in different ways. From an analytical perspective, the integration of Pólya's stages and Duval's framework proved effective in capturing the complexity of students' thinking processes. Each stage of problem solving revealed different aspects of visualization, construction, and reasoning, providing a holistic understanding of how students approach geometry problems is presented in Figure 4.

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Polya Stage	TPMG (1)	TPMG (2)
Understanding the Problem	In TPMG (1), RPM demonstrates a geometric thinking process through the ability to visualize the geometric objects involved in the problem. RPM is able to identify shapes and their elements, such as side lengths and their relationships. This understanding is supported by repeated reading. RPM also shows an effort to comprehend mental representations and the relationships between geometric elements before solving the problem.	In TPMG (2), RPM again demonstrates visualization ability and identification of basic geometric elements, both from the given information and from the problem's objective. However, this reading process is not repeated. This indicates consistency in geometric understanding and mental representation of the problem.
Planning the Solution	In TPMG (1), RPM's geometric thinking process appears when analyzing the necessary geometric concepts and relationships to solve the problem. RPM cannot yet determine an appropriate strategy based on geometric properties because the steps are not structured sequentially. This shows that the geometric analysis is done mentally but not yet systematically organized.	In TPMG (2), RPM is able to determine geometric concepts and steps more clearly. However, the planning process is still written in a less structured way. This indicates that although geometric understanding and relationships have been formed, the organization of the solution strategy remains linear.
Carrying Out the Plan	In TPMG (1), RPM integrates geometric concepts in a less systematic manner. Although the reasoning steps are not clearly structured, RPM still uses appropriate geometric concepts. The correct final result indicates that the irregularity lies in the process steps rather than in conceptual understanding.	In TPMG (2), the implementation stage remains less structured. RPM consistently applies relevant geometric concepts with logical reasoning. However, steps are still not systematically organized, and results are obtained through a closer approximation process. This reflects limitations in organizing the geometric thinking process.
Looking Back (Checking)	In TPMG (1), the checking process is not clearly visible. However, interview results show that RPM reflects mentally on the geometric solution by reassessing the suitability of the solution to the problem conditions.	In TPMG (2), RPM also does not explicitly write the checking process, but implicitly confirms the correctness of the calculations. This indicates that evaluation and geometric reflection are carried out implicitly.

Figure 4. TPMG Data Consistency Table of Male and Female Students

In conclusion, the results of this study show that geometric thinking processes vary between students, particularly when viewed from a gender perspective. These differences are reflected not in the correctness of answers, but in the ways, students organize, represent, and communicate their thinking during problem solving.

Conclusion and Suggestion

This study aimed to analyze students' geometric thinking processes in solving geometry problems based on gender differences using Pólya's problem-solving stages and the components of geometric thinking, namely visualization, construction, and reasoning. The findings indicate that both male and female students were able to successfully complete all stages of problem solving, including understanding the problem, devising a plan, carrying out the plan, and looking back, which resulted in correct final answers. However, the study reveals that differences between male and female students are more evident in the characteristics of their thinking processes rather than in their performance outcomes. The male student tended to process information internally, demonstrating implicit visualization, flexible planning, concise reasoning, and mental verification. In contrast, the female student showed a more explicit and systematic approach by clearly documenting known and unknown information, using detailed visual representations, organizing solution steps, and providing structured reasoning and written reflection.

These differences indicate that geometric thinking is a complex cognitive process influenced by individual characteristics, including gender-related cognitive tendencies. Visualization, construction, and reasoning were present in both students' thinking processes, but they were expressed in different ways, particularly in terms of representation, organization, and communication of ideas. Furthermore, the findings highlight that some aspects of students' thinking processes, especially planning and reflection, are not always fully captured in

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written responses. The use of interviews was essential in revealing these hidden cognitive processes, emphasizing the importance of employing multiple data collection methods in analyzing students' thinking. Overall, this study concludes that while gender does not significantly affect the correctness of problem-solving results, it influences how students' approach, organize, and express their geometric thinking processes. Therefore, understanding these differences is important for developing more effective and inclusive mathematics instruction.

Based on the findings of this study, several suggestions are proposed for mathematics education practice and further research. First, teachers are encouraged to focus not only on students' final answers but also on their thinking processes during problem solving. Emphasizing the stages of understanding, planning, executing, and reflecting can help students develop more structured and meaningful problem-solving skills.

Second, teachers should provide opportunities for students to express their thinking explicitly, both verbally and in written form. Encouraging the use of diagrams, explanations, and step-by-step reasoning can help students strengthen their visualization, construction, and reasoning abilities in geometry.

Third, instructional strategies should accommodate different thinking styles among students. Since male and female students may demonstrate different approaches in organizing and representing their thinking, teachers need to create learning environments that are flexible and inclusive, allowing students to explore various problem-solving strategies.

Fourth, it is important to integrate activities that promote reflective thinking, such as asking students to recheck their answers and explain their reasoning. This can help make the reflection stage more visible and improve students' overall understanding of geometric concepts.

Finally, for future research, it is recommended to involve more participants with varying levels of mathematical ability to obtain a broader perspective on students' geometric thinking processes. Further studies may also explore other influencing factors, such as learning styles, instructional methods, or technological tools, to enrich the understanding of how students develop geometric thinking in different contexts.

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