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**GENDER DYNAMICS OF MATHEMATICAL PROBLEM SOLVING IN 3D GEOMETRY:  
A CASE STUDY OF SECONDARY SCHOOL STUDENTS**

**Deti Sri Rahayu<sup>1</sup>, Mardianto<sup>2</sup>, Gemi Susanti<sup>1</sup>, Hodiyanto<sup>3\*</sup>**

<sup>1</sup>Department of Mathematics Education, Faculty of Teacher Training and Education, Universitas Sembilanbelas November Kolaka, Pemuda Street No. 339, Tahoa, Kolaka District, Kolaka Regency, Southeast Sulawesi, Indonesia

<sup>2</sup>Department of Computer Science, Faculty of Information Technology, Universitas Sembilanbelas November Kolaka, Pemuda Street No. 339, Tahoa, Kolaka District, Kolaka Regency, Southeast Sulawesi, Indonesia

<sup>3</sup>Department of Mathematics Education, Education Faculty of Mathematics and Natural Sciences and Technology, Universitas PGRI Pontianak, Ampera Street No. 88 Pontianak Indonesia

\*email: [hodiyanto@upgripnk.ac.id](mailto:hodiyanto@upgripnk.ac.id)

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**Abstrak**

Penelitian ini bertujuan menganalisis kemampuan pemecahan masalah matematis siswa pada materi geometri ruang dengan mengacu pada empat tahap Polya: memahami masalah, merencanakan penyelesaian, menyelesaikan masalah sesuai rencana, dan memeriksa kembali. Data diperoleh melalui tugas tertulis berbentuk soal geometri limas dan wawancara mendalam terhadap satu siswa laki-laki dan satu siswa perempuan. Hasil analisis menunjukkan bahwa siswa laki-laki mampu memahami masalah, merencanakan langkah, dan menyelesaikan perhitungan dengan benar, namun melakukan kesalahan prosedural kecil berupa kelalaian menuliskan tanda akar saat menerapkan Teorema Pythagoras. Siswa perempuan menghadapi kesalahan konseptual dan prosedural yang lebih kompleks, seperti menukar konsep volume dan luas permukaan, salah menentukan tinggi segitiga bidang, serta keliru menghitung luas bidang. Wawancara menegaskan bahwa sebagian besar kesalahan muncul karena ketidaktepatan dalam mengaitkan konsep dua dimensi dan tiga dimensi, meskipun siswa memahami perbedaan istilah. Temuan ini mengindikasikan bahwa penguasaan konsep geometri ruang harus disertai ketelitian prosedural dan representasi multi-dimensi agar pemecahan masalah berjalan efektif. Studi ini merekomendasikan penguatan pembelajaran berbasis multi-representasi, latihan analisis kesalahan, dan konteks nyata untuk meminimalkan miskonsepsi geometri dan meningkatkan ketelitian pemecahan masalah.

**Kata kunci:** pemecahan masalah matematis, geometri ruang, kesalahan konseptual, kesalahan prosedural, tahap Polya

**Abstract**

*This study aims to analyze students' mathematical problem-solving abilities in three-dimensional geometry using Polya's four stages: understanding the problem, devising a plan, carrying out the plan, and looking back. Data were collected through a written geometry task on pyramid solids and in-depth interviews with one male and one female student. The findings reveal that the male student successfully understood the problem, planned the solution, and executed calculations accurately, yet made a minor procedural error by omitting the square root symbol when applying the Pythagorean theorem. The female student experienced more complex conceptual and procedural errors, including confusing volume with surface area, misidentifying the altitude of the triangular face, and miscalculating its area. Interviews confirmed that these errors stemmed largely from inattention to the relationships between*



*two- and three-dimensional concepts, despite an overall awareness of the distinctions. These results indicate that mastery of spatial geometry requires both strong conceptual understanding and procedural accuracy, supported by multi-dimensional representations to ensure effective problem solving. The study recommends incorporating multi-representational teaching, structured error analysis, and real-world contexts to reduce geometry misconceptions and enhance precision in mathematical problem-solving.*

**Keywords:** *mathematical problem solving, space geometry, conceptual errors, procedural errors, Polya's stages*

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## INTRODUCTION

Mathematical problem-solving ability is one of the important abilities that students need to have in learning mathematics. Mathematical problem-solving ability is defined as an individual's ability to identify, understand, and solve problems involving mathematical concepts using appropriate strategies. This process involves understanding the problem, devising a plan, carrying out the plan, and looking back (Polya's stages) (Amalina & Vidákovich, 2023; Nugraha, 2022; Son et al., 2020). Bell & Polya(1945) put forward four important steps in mathematical problem solving: (1) Understanding the problem, that is, before solving a problem, the problem solver needs to have a good understanding of the problem at hand. This includes understanding the data provided, the questions asked, and the context of the problem. (2) Devising a plan, after understanding the problem, the next step is to plan how to solve it. This can include choosing the right strategy, such as using formulas, diagrams, or other mathematical principles. (3) Carrying out the plan, after the plan is made, the problem solver carries out the steps to reach the solution, and (4) Looking back, after obtaining a solution, it is important to recheck the results and evaluate whether the solution is indeed appropriate and adequate. Problem-solving abilities are also one of the learning objectives that must be achieved by students in Indonesia, according to the Minister of Education and Culture Regulation (2025).

Furthermore, mathematical problem-solving abilities can be an indicator of student learning outcomes. This means that the higher a student's problem-solving abilities, the higher their learning outcomes (Hodiyanto, 2017a). Several research studies have shown that students' mathematical problem-solving abilities are generally low (Hodiyanto et al., 2020; Yani et al., 2021, 2022). Students often make mistakes in solving 3D geometry story problems because they are not careful enough in recording the conclusions from their calculations (Muhassanah & Setiani, 2024; Wibowo et al., 2024). Therefore, this research needs to be continued to analyze students' problem-solving abilities and the problems faced by students that contribute to their low problem-solving abilities. By analyzing students' mathematical problem-solving abilities in-depth and the challenges they encounter, it is hoped that solutions can be found to enhance the effectiveness of mathematics learning and improve students' mathematical problem-solving abilities. This research is important for providing a clearer picture of the obstacles faced by students and offering recommendations for enhancing students' mathematical problem-solving abilities, ultimately improving mathematics learning outcomes in schools.

In addition, external factors such as students' attitudes and perceptions of mathematics, which are influenced by gender, also play a significant role in this process. Persistent social stereotypes often associate males with better mathematical abilities than females, which can influence how students

solve math problems and how they assess their own abilities in this area (Boaler, 2022; Hyde et al., 2008). The stereotype that boys are more capable in mathematics and more confident in dealing with it often oppresses female students, which in turn affects the way they solve math problems. Lindberg et al. (2010) showed in their research that, although there are no fundamental differences in mathematical abilities between the two genders, social and cultural influences still affect the way male and female students approach and solve mathematical problems. Previous research also showed that there are differences in analogical reasoning between male and female students before being given scaffolding (Hodiyanto & Juniati, 2022). However, several research results also show that there is no difference in students' mathematical abilities based on gender (Hodiyanto, 2014, 2017b). Countries or regions with higher levels of gender equality tend to show smaller gender gaps in mathematics (Cascella et al., 2022). In this context, this study aims to explore the gender dynamics in mathematical problem-solving in secondary schools and how these factors influence the approach and solution methods of students of both genders.

Although numerous studies have examined the relationship between gender and mathematical problem solving, the results still show mixed findings. Gender differences in problem-solving may arise due to variations in abilities, interests, and influences that are relevant to collaborative problem-solving performance (Borgonovi et al., 2023). The literature has identified significant gender gaps in terms of interest and influence (Wang & Degol, 2017; Xie et al., 2015). Several research results show that there are no significant differences between men and women in problem-solving abilities, both in the context of metacognition, critical thinking abilities, and problem-solving test results. However, some studies have found small differences in certain aspects or types of tasks, such as reflective strategies or spatial tasks; however, these differences are inconsistent and often not statistically significant (Deng et al., 2023; Jakhar, 2019). However, some studies show that women tend to excel in collaborative, reflective, and mathematical problem solving in general, as well as being more thorough and holistic. In contrast, men excel in specific cognitive aspects, such as spatial ability, numerical ability, flexible strategies, and speed; however, the results can vary depending on the context, type of task, and affective factors, including self-confidence and emotions (Borgonovi et al., 2023; Putriani & Purnomo, 2025). Women are more anxious about mathematics than men, and this impacts their ability to solve problems (Henschel et al., 2023; Khasawneh et al., 2021). Therefore, even though there is no difference in basic abilities between men and women in mathematics, psychological factors influenced by gender stereotypes can affect their success in solving mathematical problems.

This research is important because it can provide deeper insight into the role of gender in the development of students' mathematical problem-solving abilities. By understanding the differences in problem-solving approaches and strategies used by boys and girls, the results of this study are expected to help teachers design more inclusive and gender-sensitive learning approaches. This knowledge can also serve as a basis for stakeholders to develop more equitable education policies, which provide equal opportunities for all students to develop their mathematical abilities without being hindered by gender stereotypes. Furthermore, this research can encourage changes in the way mathematics is taught, focusing not only on mastering technical concepts but also on developing self-confidence and positive attitudes towards mathematics, especially for female students who often feel hampered by existing stereotypes.

By paying closer attention to gender differences in mathematics education, this research is expected to encourage policies that are more responsive to students' needs. Teachers who understand gender dynamics can adapt their teaching methods to address barriers faced by female students, such as math anxiety, and provide better support for all students, regardless of gender. Furthermore, the results of this study can also make a positive contribution to efforts aimed at creating more inclusive learning environments and reducing inequalities in mathematics education. The purpose of this study is to describe students' mathematical problem-solving abilities in terms of gender.

## METHOD

This study used a case study method to analyze and explore (Lavarda & Bellucci, 2022) the mathematical problem-solving abilities of male and female students. The researcher acted as the primary instrument, interacting directly with the research subjects, namely the students selected for this study. The researcher was tasked with collecting, analyzing, and interpreting the obtained data, as well as ensuring the validity of the findings by referring to a clear and systematic methodology. The subjects in this study were selected using purposive sampling: students with high mathematical abilities, as identified by teachers who taught the classes and were willing to be interviewed after completing the assignment. This approach enabled the researcher to investigate the differences in mathematical problem-solving abilities between male and female students. The instrument used in this study consisted of two main components: a mathematical problem-solving task and a task-based interview guide. The task instrument was designed to measure how students solved the given mathematical problems, focusing on aspects of the problem-solving strategies and the steps taken during the solution process. Each student, regardless of gender, was given a similar task to ensure that the data obtained could be compared fairly. Additionally, the task-based interview guide was used to explore the reasons, thought processes, and strategies employed by students in solving the task. This interview aimed to understand students' perspectives on how they approach problem-solving and the factors that influence their decision-making.

To ensure the credibility of the findings, this study employed method triangulation, combining data obtained from two methods: problem-solving tasks and task-based interviews. This approach enabled the researcher to verify the existing findings, ensuring that the results from the tasks and interviews complemented and supported one another. Thus, the credibility and validity of the findings were maintained, ensuring that the results of this study could be relied upon to answer the research objectives. The data analysis process was conducted using the data analysis model proposed by Miles et al. (2014), which consists of three main stages: first, data reduction, which involves selecting and simplifying data relevant to the research focus. At this stage, data obtained from assignments and interviews will be grouped into relevant categories, such as the types of strategies used in problem-solving. Second, data presentation, where the reduced data is arranged in a more structured format, such as tables or descriptive narratives, to facilitate understanding. Finally, in the conclusion-drawing stage, researchers will draw conclusions based on the analysis that has been conducted, as well as evaluate differences in problem-solving abilities between male and female students. The resulting conclusions will include findings regarding factors that influence students' mathematical abilities based on their gender. The task used in this study is:

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„Susanti bought a pyramid-shaped mendut cake with a square base with a base edge length of 6 cm and a volume of 48 cm.

What is the surface area of the pyramid-shaped mendut cake?

- Write down what is known and what is asked in the question above!
- How to solve the problem above?
- Complete the problem according to the plan?
- Please recheck your answers and draw a conclusion!



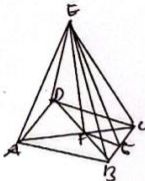
## RESULTS AND DISCUSSION

The research results that will be presented in this article are the results relating to students' problem-solving abilities. The subjects in this study consist of one male and one female, all of whom have moderate abilities.

### Mathematical Problem-Solving Ability of Male

Figure 1 illustrates male students' responses in solving mathematical problems based on the assessed indicators.

mendat model limas  
 rusuk alas (s) 6 cm volume (V) 48 cm<sup>3</sup>  
 berapakah luas permukaannya



$$V = \frac{1}{3} \times LA \times t$$

$$48 \text{ cm}^3 = \frac{1}{3} \times 6^2 \times EF$$

$$48 \text{ cm}^3 = \frac{1}{3} \times 36 \times EF$$

$$EF = 4$$

TL. sisi tegak =  $EG = \sqrt{EF^2 + \delta F}$   
 $EG = \sqrt{4^2 + 3^2}$   
 $= \sqrt{25}$   
 $= 5$

L. sisi tegak =  $\frac{1}{2} BC \times EG$   
 $= \frac{1}{2} \times 6 \times 5$   
 $= 15$

LP. mendat =  $LA + 4(L. sisi tegak)$   
 $= 6 \times 6 + 4(15)$   
 $= 36 + 60$   
 $= 96 \text{ cm}^2$

Figure 1. Results of Male Students' Answers

This male student's work can be analyzed through the four stages of problem-solving, as outlined by Bell and Pólya (1945): understanding the problem, devising a plan, carrying out the plan, and looking back. Interviews with male students provide a more complete description of their thinking during the task-solving process. At the problem-understanding stage, the student demonstrates a good understanding of the information provided in the assignment. He writes that the shape in question was a pyramid with a volume of 48 cm<sup>3</sup> and a square base edge, and he understood that the required surface area was required. The drawing of the pyramid with clear vertices indicates that the male student recognizes important elements such as the base, height, and right edge. Interview results confirm this. He states that before calculating, he always reads the problem twice and writes down important data to avoid confusion and redraws the shape to make it easier to visualize the height and slant height. This demonstrates metacognitive awareness in understanding the context of the problem.

In devising a plan, he arranges the steps coherently and systematically. He first uses the pyramid volume formula to find the height of the pyramid, then plans to use the Pythagorean theorem to determine the length of the slant edge of the vertical side. After that, he calculates the area of one vertical side and multiplies it by four for all sides, then adds the area of the base and all four vertical sides to obtain the surface area. In the interview, he explains that he writes the formula first so that he will not forget the order and ensure each step is correct before moving on to the next stage. This statement demonstrates the ability to design a structured strategy.  $V = \frac{1}{3} \times \text{Luas Alas} \times \text{tinggi}$

In carrying out the plan, he performs the calculations systematically. He calculates the height of the pyramid as 4 cm from the volume formula, determines the slant edge using the Pythagorean theorem to obtain a length of 5 cm, then calculates the area of one vertical side of 15 cm<sup>2</sup>, and

concludes with the calculation of the total surface area of 96 cm<sup>2</sup>. However, there is a small error when the student wrote the calculation of the length of EG using the Pythagorean theorem, namely, not writing the root symbol in the GF calculation section when finding EG. Although conceptually and the result are correct, this step appeared incomplete in writing. Based on the interview results, he states that he understands the importance of writing the root. However, at that time, he forgot to write it because he focused on the numerical calculation. This indicates that conceptually, he has mastered the material, but there was a minor omission in the presentation.

During the looking backstage, the answer sheet does not indicate a written rechecking process, but interviews reveal that the student did recheck. He mentions that he quickly calculated in his head:  $6 \times 6 = 36$ , four sides =  $4 \times 15 = 60$ , total 96, and felt the result was correct. Although not recorded, the habit of internal checking indicates a final evaluation. Overall, the student's answers demonstrate good mathematical problem-solving abilities across all four Pólya stages. He clearly understands the problem, devises a coherent plan, carries out the calculation according to the plan correctly despite a minor omission in the radical symbol, and performs an internal check, although not written down. The interviews confirm that the student possesses metacognitive awareness, a habit of planning steps before calculating, and a consistent mental check method. These results indicate that the student's problem-solving abilities are mature and structured.

### Mathematical Problem-Solving Ability of Female Students

The female students' answers to the mathematical problem-solving ability task can be seen in Figure 2.

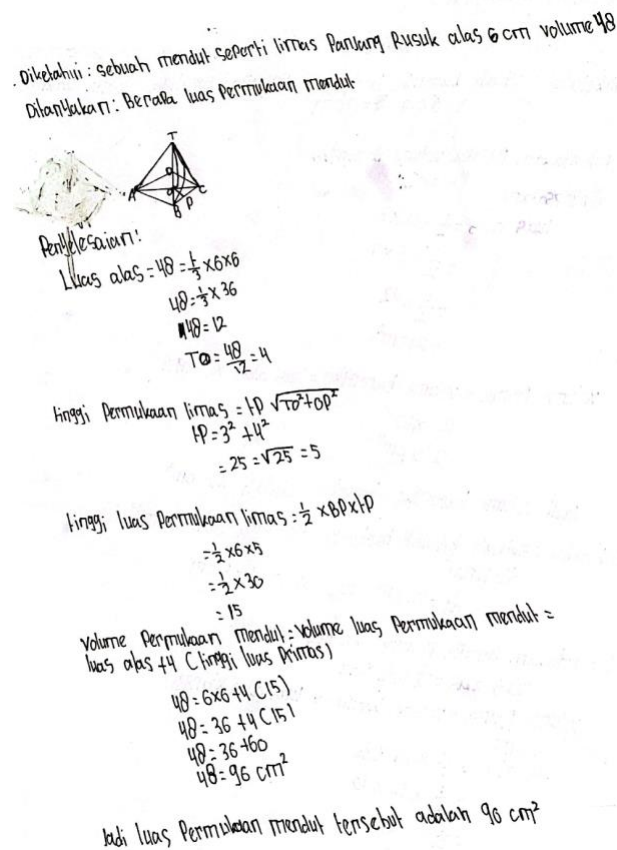


Figure 2. Results of Female Students' Answers

At the problem understanding stage, she appears to correctly identify the key information: a pyramid with a base edge of 6 cm and a volume of 48 cm<sup>3</sup>, and the required surface area. She also sketches the pyramid and includes the data on the worksheet, indicating that she attempted to map the

relevant geometric elements before calculating. In the interview, she confirms that she has indeed copied the problem data and created a sketch to facilitate understanding.

In the devising a plan stage of the solution, she develops a logical strategy: determines the height of the pyramid from the volume formula, then use the Pythagorean theorem to find the length of the hypotenuse of a right-sided triangle, calculates the area of one right-sided triangle (triangle), and finally adds the area of the base and the area of the four right-sided sides to obtain the surface area. Interviews confirm that she deliberately wrote down these formulas first so that the steps were structured.  $V = \frac{1}{3} \times \text{Luas Alas} \times \text{tinggi}$

In carrying out the plan phase, although the general steps and final calculations (pyramid height = 4 cm, slant height = 5 cm, area of one perpendicular face = 15 cm<sup>2</sup>, total surface area = 96 cm<sup>2</sup>) are correct, there are several errors in writing and labeling concepts that are worth noting. First, she writes an expression that shows 48 as "area" at the beginning (e.g., writing "Area of the base = 48 = "), when 48 is actually the volume of the pyramid. This mislabeling can be confusing to readers. Based on the interview, she realizes that 48 is the volume, not the area, and acknowledges this error. Second, in the process of finding the height of triangle BCT and calculating the area of triangle BCT, she writes the term "pyramid height" several times when what should be found and used is the height of triangle BCT; according to his statement during the interview, she understands that he should focus on triangle BCT, but mislabeled the steps. Third, when asked to explain why the volume appears to be written as the same as the area on the worksheet, she is unable to provide a reason. She can not explain why the two quantities were mixed up in his notes, although when asked whether area was the same as volume, she answers that they are different and emphasizes that she is indeed looking for the surface area of a pyramid. In conclusion, conceptually and numerically, she understands the steps to be taken, but there are omissions in the labeling of variables and consistency of terminology that made the written steps imprecise.

During the review stage, the worksheet shows the word "so" at the end of the work, a sign that could be interpreted as an attempt at a quick check. Interviews confirmed that she did indeed check her results. However, because some conceptual errors were not erased from the paper, the check was partial: she is aware of and verbally acknowledged some errors (e.g., 48 is volume, not area; she should have found the height and area of triangle BCT), but when asked to provide reasons for some inconsistencies, she is unable to explain them. This suggests reflection is present but not fully captured in written notes. Overall, the female student demonstrates good mathematical problem-solving ability, but needed to improve the accuracy of symbolization, labeling, and naming quantities (e.g., distinguishing volume from area, and clearly marking "height of triangle BCT" instead of "surface height of pyramid") and implement more systematic review of her worksheet to ensure that presentational errors do not obscure true conceptual understanding.

Analysis of the two students shows that at the problem-understanding stage, both a male and a female can accurately identify important information, such as the dimensions of the base, height, and volume of the geometric figure. They also understand that the question was asking for the surface area of the pyramid. These findings support the study by Bu et al. (2025), which emphasizes that the ability to extract relevant information is a crucial foundation for problem-solving. Students who master this stage tend to be better prepared to design effective problem-solving strategies. In devising a plan, both students demonstrated clear strategic plans. The male student plans systematic steps: determining the height of the pyramid through the relationship between the volume and area of the base, calculating the hypotenuse using the Pythagorean Theorem, and then adding the areas of the base and the perpendicular plane. The female student also planned similar steps. These results align with previous findings that a thorough planning stage is crucial for reducing errors and enhancing accuracy during execution (Lathifaturrahmah et al., 2024; Mustofa et al., 2020). Students with better planning abilities showed higher mathematical problem-solving performance (Elbistan & Stubbe, 2021).

The devising of a plan is the most obvious difference. The male student executes the calculations sequentially and correctly, but made a procedural error by forgetting to write the radical sign when applying the Pythagorean Theorem to find the length of EG. Interviews confirm that this error is purely due to forgetfulness, not a lack of conceptual understanding. This type of error is categorized as a procedural lapse (forgetting to write a symbol/operation), which, according to Hiebert & Grouws (2007), often occurs when students focus on the logical flow of calculations and ignore formal notation. Students who understand mathematical concepts well can still make notation errors, especially if they are not used to checking or understanding the rules for writing symbols correctly. These errors are often not due to a lack of conceptual understanding, but rather to a lack of knowledge of symbolic conventions (mathematical orthography) or the habit of checking the correctness of notation (Douglas et al., 2020; Wardah et al., 2021). The female student, on the other hand, exhibits a deeper combination of conceptual and procedural errors. She writes the volume as the area of a pyramid, misinterpreting the height of triangle BCT as the "surface height of the pyramid," and misrepresenting the process for calculating the area of triangle BCT. Although the interview indicated that she is aware of the difference between volume and area, she was unable to explain her reasoning for writing volume as area. Sisman & Aksu (2016) and Machaba et al. (2024) reveal that students often mix up the volume and surface area formulas, for example using the volume formula to calculate surface area or vice versa and students also often fail to differentiate units of measurement ( $\text{cm}^2$  for area,  $\text{cm}^3$  for volume) and do not understand the difference in meaning between the two. In addition, the inaccuracy in finding the height of the triangle BCT by writing the height of the pyramid surface also shows the weakness of students' conceptual understanding.

The rechecking stage indicates a process of reflection, although the quality varies. She does not explicitly check, but interviews confirm that she did. She concludes their answers with the word "so," indicating an awareness of the importance of the conclusion. Students who rechecked tended to be more confident in their answers, able to detect and correct errors, and improve the quality of their solutions (Jean & Ellissi, 2025; Pathuddin et al., 2022). However, as in the case of female students, examinations without in-depth understanding are not enough to correct misconceptions.

Overall, this comparison highlights that minor procedural errors (missing symbols) are fundamentally different from conceptual-procedural errors (misconceptions and steps). These findings suggest that teachers should provide explicit space for verification exercises, such as checking units, symbols, and conceptual consistency, and facilitate visual representations to strengthen understanding of the relationship between volume and area. These findings provide a practical foundation for designing more effective geometry learning. First, teachers need to integrate error analysis activities so that students become accustomed to identifying and correcting both procedural and conceptual errors. Second, the use of models and visual representations that emphasize the differences between two dimensions and three dimensions can reduce misconceptions between area and volume. Third, the habit of reflection, for example, through discussions after checking results, should be encouraged. Thus, the results of this study contribute to the development of mathematics learning that emphasizes a balance between conceptual understanding, procedural accuracy, and reflective abilities, enabling students to execute problem-solving plans accurately while simultaneously detecting and correcting errors independently.

## CONCLUSION

Analysis of geometry problem-solving using Polya's four-step framework revealed clear differences between the two students. Based on the results of this study, it was found that the male student was able to understand the problem, plan the steps, and complete the calculations correctly, but made a minor procedural error, such as forgetting to write the radical sign. In contrast, the female student made more complex conceptual and procedural errors, such as interchanging the concepts of volume and area, incorrectly determining the height of a plane triangle, and incorrectly calculating

the area. Interviews reveal that she is aware of the difference between volume and area, but does not apply it consistently. These findings confirm that successful problem-solving depends not only on mastery of formulas but also on strong representations of two- and three-dimensional concepts and procedural accuracy. Based on these findings, teachers are advised to reinforce 2D–3D concepts through a multi-representational approach that combines physical models, pictures, and symbols, so that the fundamental differences between area and volume become clearer to students. Teachers should also emphasize procedural accuracy practice by getting students used to writing down each step and formal symbols, to avoid simple errors such as forgetting the radical sign. Furthermore, integrating error analysis activities into learning will help students learn from real-life errors and train them to identify and correct misconceptions. Real-life context-based geometry learning approaches, such as spatial-figure projects that link height, surface area, and volume, are also important for strengthening spatial understanding and problem-solving abilities.

Future research requires error analysis studies to reduce geometry misconceptions. Comparative research across educational levels and cultures is also relevant to gain a broader understanding of the variations in conceptual and procedural errors. Furthermore, exploring the use of 3D visualization technology or augmented reality is worthwhile to strengthen spatial understanding and reduce problem-solving errors. Furthermore, research into the development of learning media that integrates ethnomathematics into 3D technology is also needed to help students improve their problem-solving skills. A weakness of this study is that it only involved two high-ability students, so further research is needed to explore the abilities of medium- and low-ability students.

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## REFERENCES

- Amalina, I. K., & Vidákovich, T. (2023). Cognitive and socioeconomic factors that influence the mathematical problem-solving skills of students. *Heliyon*, 9(9), e19539. <https://doi.org/10.1016/j.heliyon.2023.e19539>
- Bell, E. T., & Polya, G. (1945). *How to solve it: A new aspect of mathematical method*. Princeton University Press. <https://doi.org/10.2307/2306109>
- Boaler, J. (2022). *Mathematical mindsets: Unleashing students' potential through creative mathematics, inspiring messages, and innovative teaching*. John Wiley & Sons.
- Borgonovi, F., Han, S. W., & Greiff, S. (2023). Gender differences in collaborative problem-solving skills in a cross-country perspective. *Journal of Educational Psychology*, 115(5), 747–766. <https://doi.org/10.1037/edu0000788>
- Bu, X., Zheng, H., Tian, X., & Luo, F. (2025). Information-reduction ability assessment in the context of complex problem-solving. *Journal of Intelligence*, 13(3), 28. <https://doi.org/10.3390/jintelligence13030028>
- Cascella, C., Williams, J. S., & Pampaka, M. (2022). Gender differences in mathematics outcomes at different levels of locality to inform policy and practice. *European Educational Research Journal*, 21(5), 705–731. <https://doi.org/10.1177/1474904121997211>
- Deng, X., Chen, S., Li, X., Tan, C., Li, W., Zhong, C., Mei, R., & Ye, M. (2023). Gender differences in empathy, emotional intelligence, and problem-solving ability among nursing students: A cross-sectional study. *Nurse Education Today*, 120, 105649. <https://doi.org/10.1016/j.nedt.2022.105649>

- Douglas, H., Headley, M. G., Hadden, S., & LeFevre, J.-A. (2020). Knowledge of mathematical symbols goes beyond numbers. *Journal of Numerical Cognition*, 6(3), 322–354. <https://doi.org/10.5964/jnc.v6i3.293>
- Elbistan, B. D. B., & Stubbe, T. C. (2021). The relationship between problem-solving skills and planning ability using the Tower of London test. *Open Education Studies*, 3(1), 226–232. <https://doi.org/10.1515/edu-2020-0157>
- Henschel, S., Jansen, M., & Schneider, R. (2023). How gender stereotypes of students and significant others relate to motivational and affective outcomes in mathematics at the end of secondary school. *Contemporary Educational Psychology*, 73, 102161. <https://doi.org/10.1016/j.cedpsych.2023.102161>
- Hiebert, J. S., & Grouws, D. A. (2007). The effects of classroom mathematics teaching on students' learning. In F. K. Lester (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 371–404). Information Age Publishing.
- Hodiyanto. (2014). Meningkatkan kemampuan berpikir kreatif siswa melalui pembelajaran pemecahan masalah ditinjau dari gender pada materi himpunan. *Jurnal Pendidikan Informatika dan Sains*, 3(1), 27–41.
- Hodiyanto. (2017a). Hubungan kemampuan pemecahan masalah matematis dan kemampuan koneksi matematis dengan prestasi belajar mahasiswa. *Jurnal Pendidikan Informatika dan Sains*, 6(2), 208–218.
- Hodiyanto. (2017b). Pengaruh model pembelajaran problem solving terhadap kemampuan komunikasi matematis ditinjau dari gender. *Jurnal Riset Pendidikan Matematika*, 4(2), 219–228. <https://doi.org/10.21831/jrpm.v4i2.15770>
- Hodiyanto, H., Darma, Y., & Putra, S. R. S. (2020). Pengembangan media pembelajaran berbasis Macromedia Flash bermuatan problem posing terhadap kemampuan pemecahan masalah matematis. *Mosharafa: Jurnal Pendidikan Matematika*, 9(2), 323–334. <https://doi.org/10.31980/mosharafa.v9i2.652>
- Hodiyanto, H., & Juniati, D. (2022). The role of scaffolding in students' geometry analogical reasoning from gender perspectives. *Jurnal Pendidikan Informatika dan Sains*, 11(1), 41–51. <https://doi.org/10.31571/saintek.v11i1.3883>
- Hyde, J. S., Lindberg, S. M., Linn, M. C., Ellis, A. B., & Williams, C. C. (2008). Gender similarities characterize math performance. *Science*, 321(5888), 494–495.
- Jakhar, L. R. (2019). Gender as a predictor of difference in problem-solving ability of students. *Shanlax International Journal of Arts, Science and Humanities*, 6(4), 52–55. <https://doi.org/10.34293/sijash.v6i4.342>
- Jean, A., & Ellissi, W. (2025). Analysis of mathematical problem-solving ability in terms of students' learning styles on arithmetic series and sequences. *Riemann: Research of Mathematics and Mathematics Education*, 7(1), 53–61. <https://doi.org/10.38114/reimann.v7i1.62>
- Khasawneh, E., Gosling, C., & Williams, B. (2021). What impact does maths anxiety have on university students? *BMC Psychology*, 9(1), 37. <https://doi.org/10.1186/s40359-021-00537-2>
- Lathifaturrahmah, L., Nusantara, T., Subanji, S., & Muksar, M. (2024). Analysis of mathematics students' problem-solving skills in making prediction mathematical representations. *AIP Conference Proceedings*, 030010. <https://doi.org/10.1063/5.0195480>
- Lavarda, R., & Bellucci, C. (2022). Case study as a suitable method to research strategy as practice perspective. *The Qualitative Report*, 27(8), 1785–1805. <https://doi.org/10.46743/2160-3715/2022.4296>
- Lindberg, S. M., Hyde, J. S., Petersen, J. L., & Linn, M. C. (2010). New trends in gender and mathematics performance: A meta-analysis. *Psychological Bulletin*, 136(6), 1123–1135.

- Machaba, M. F., Sibanda, A., & Fasinu, V. (2024). Grade 8 learners' perceptions and misconceptions on surface area and volume in mathematics. *International Journal of Management, Knowledge and Learning*, 13, 377–400. <https://doi.org/10.53615/2232-5697.13.377-400>
- Miles, M. B., Huberman, A. M., & Saldaña, J. (2014). *Qualitative data analysis: A methods sourcebook* (3rd ed.). SAGE Publications.
- Muhassanah, N., & Setiani, A. (2024). Analysis of student errors based on Polya's steps in three-dimensional geometry. *Union: Jurnal Ilmiah Pendidikan Matematika*, 12(2), 340–349. <https://doi.org/10.30738/union.v12i2.17575>
- Mustofa, B., Mardiyana, & Slamet, I. (2020). An analysis of problem-solving ability in linear equation systems with two variables. *Journal of Physics: Conference Series*, 1538(1), 012099. <https://doi.org/10.1088/1742-6596/1538/1/012099>
- Nugraha, I. D. (2022). Students' mathematical problem-solving ability on social arithmetic material. *Journal of Innovation and Research in Primary Education*, 1(2), 33–39. <https://doi.org/10.56916/jirpe.v1i2.171>
- Permendikdasmen. (2025). *Capaian pembelajaran pada pendidikan anak usia dini, jenjang pendidikan dasar, dan jenjang pendidikan menengah*. Kementerian Pendidikan Dasar dan Menengah, Badan Standar, Kurikulum, dan Asesmen Pendidikan.
- Putriani, F. M., & Purnomo, Y. W. (2025). Analysis of mathematical reflective thinking skills in solving problems in terms of gender differences. *Jurnal Paedagogy*, 12(2), 285–294. <https://doi.org/10.33394/jp.v12i2.14758>
- Sisman, G. T., & Aksu, M. (2016). A study on sixth grade students' misconceptions and errors in spatial measurement: Length, area, and volume. *International Journal of Science and Mathematics Education*, 14(7), 1293–1319. <https://doi.org/10.1007/s10763-015-9642-5>
- Son, A. L., Darhim, D., & Fatimah, S. (2020). Students' mathematical problem-solving ability based on teaching models intervention and cognitive style. *Journal on Mathematics Education*, 11(2), 209–222. <https://doi.org/10.22342/jme.11.2.10744.209-222>
- Wang, M.-T., & Degol, J. L. (2017). Gender gap in science, technology, engineering, and mathematics (STEM): Current knowledge, implications for practice, policy, and future directions. *Educational Psychology Review*, 29(1), 119–140. <https://doi.org/10.1007/s10648-015-9355-x>
- Wardah, S., Utomo, D. P., & Putri, O. R. U. (2021). An analysis of errors on mathematical symbols as metaphors in linear programming. *Jurnal Didaktik Matematika*, 8(1), 45–58. <https://doi.org/10.24815/jdm.v8i1.18304>
- Wibowo, A., Syaekhu, A., & Amin, R. (2024). Analysis of students' errors in solving mathematics story problems on the system of linear equations with two variables. *Journal of Digital Learning and Distance Education*, 2(12), 872–878. <https://doi.org/10.56778/jdlde.v2i12.259>
- Xie, Y., Fang, M., & Shauman, K. (2015). STEM education. *Annual Review of Sociology*, 41(1), 331–357. <https://doi.org/10.1146/annurev-soc-071312-145659>
- Yani, A., Prihatin, I., Hodiyo, H., & Sumiati, S. (2021). Android-based learning media design with contextual learning to develop problem-solving skills. *Jurnal Didaktik Matematika*, 8(2), 148–159. <https://doi.org/10.24815/jdm.v8i2.18555>
- Yani, A., Susiaty, U. D., Agustami, A., & Hodiyo, H. (2022). Integration of character education in Android-based m-learning media on problem-solving ability. *Jurnal Pendidikan Informatika dan Sains*, 11(2), 135–147. <https://doi.org/10.31571/saintek.v11i2.4816>