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Students' Mathematical Spatial Ability in Terms of Gender: A Case Study of A Female Student with High Mathematical Spatial Ability

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Abstract:

This study was motivated by the contradiction between the general assumption that male students have higher mathematical spatial abilities than female students and the findings of a female student who shows high mathematical spatial performance. In addition, in-depth studies of female students with high mathematical spatial abilities are still limited in the literature. This study aims to find out "how" and "why" a female student has high mathematical spatial ability. This research uses a qualitative type with a case study design and an interpretative approach. The research subject was a female student at SMPN 68 Jakarta who was identified as having high mathematical spatial ability based on the initial observation of 66 students. Data were collected through the administration of three sets of mathematical spatial ability problems, semi-structured interviews, and non-systematic observations. The results showed that the female student was able to solve the spatial problems consistently and obtained the maximum score in all three problem sets. She showed a systematic solution strategy by reading and thoroughly understanding the information in the problem, and using her spatial imagination. Factors that support the student's high mathematical spatial ability include learning that encourages concept understanding, independent learning habits, involvement in tutoring and private lessons, experience participating in math olympiads, support from family and friends, and the habit of playing space-based games.

Abstrak:

Penelitian ini dilatarbelakangi oleh adanya kontradiksi antara asumsi umum yang menyatakan bahwa siswa laki-laki memiliki kemampuan spasial matematis lebih tinggi dibandingkan siswa perempuan dengan temuan seorang siswa perempuan yang justru menunjukkan performa spasial matematis tinggi. Selain itu, kajian mendalam terhadap siswa perempuan dengan kemampuan spasial matematis tinggi masih terbatas dalam literatur. Penelitian ini bertujuan untuk mengetahui "bagaimana" dan "mengapa" seorang siswa perempuan memiliki kemampuan spasial matematis tinggi. Penelitian ini menggunakan penelitian kualitatif dengan desain studi kasus dan pendekatan interpretatif. Subjek penelitian adalah seorang siswa perempuan di SMPN 68 Jakarta yang teridentifikasi memiliki kemampuan spasial matematis tinggi berdasarkan hasil observasi awal terhadap 66 siswa. Data dikumpulkan melalui pemberian tiga paket soal kemampuan spasial matematis, wawancara semi terstruktur, dan observasi non-sistematis. Hasil penelitian menunjukkan bahwa siswa perempuan tersebut mampu menyelesaikan soal-soal spasial secara konsisten dan memperoleh skor maksimal pada ketiga paket soal. Ia menunjukkan strategi penyelesaian yang sistematis, dengan membaca dan memahami secara menyeluruh informasi pada soal, serta menggunakan pengimajinasian spasialnya. Faktor-faktor yang mendukung kemampuan spasial matematis tinggi siswa tersebut antara lain pembelajaran yang mendorong pemahaman konsep, kebiasaan belajar mandiri, keterlibatan dalam bimbingan belajar dan les privat, pengalaman mengikuti olimpiade matematika, dukungan dari keluarga dan teman, serta kebiasaan bermain game berbasis ruang.

Keywords:
Mathematical Spatial Ability, Gender, Female Student

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INTRODUCTION

Mathematical spatial ability plays an important role in learning mathematics, especially in the material of building space (Imamuddin & Isnaniah, 2018). Achdiyat and Utomo (2018) stated that this ability helps students in understanding abstract ideas by involving spatial perception, orientation, and the ability to mentally manipulate and rotate objects. In line with that, Nuraini, Sunardi, Ambarwati, Hobri, and Jatmiko (2022) defined spatial ability as a person's capacity to think in the form of images or visualizations, which includes storing, processing, and reproducing visual and spatial aspects of the surrounding environment. Thus, mastery of mathematical spatial ability is a crucial aspect in supporting the understanding of abstract concepts in mathematics, especially in spatial building materials that require visualization, spatial perception, and mental manipulation of spatial objects.

Several studies have shown some of the difficulties experienced by students in understanding the concept of spatial shapes and solving problems involving spatial modeling. Sahara and Nurfauziah (2021) found that students experienced obstacles in examining the properties of flat-sided spaces, especially in drawing deductive conclusions, due to a lack of understanding of geometry concepts. Dewi, Maimunah, and Roza (2022) identified that internal factors, such as the assumption that geometry is difficult and uninteresting learning, as well as external factors, such as a lack of support during learning, contribute to students' low mathematical spatial abilities. In addition, Suprayo, Sugiman, Pujiastuti, Setiyani, and Oktoviani (2023) stated that students have difficulty in determining the known and questionable information in the problem, making a solution plan, and applying the right strategy in solving space building problems.

Gender is a concept that refers to differences in roles, behaviors, and social expectations between men and women (Cislaghi & Heise, 2020). In the context of mathematical spatial ability, several studies in cognitive psychology (Maccoby & Jacklin, 1974; Voyer, Voyer, & Bryden, 1995), biology (Yuan, Kong, Luo, Zeng, Lan, & You, 2019), and mathematics education (Ismi, Al, Kurniawati, & Negara, 2021; Suparmi, Budayasa, & Setianingsih, 2022) show that male students tend to perform better than female students. This difference is thought to be related to the way male and female students process and solve problems, which in turn affects how they acquire and construct mathematical knowledge (Astuti & Supiat, 2023).

In this study, the researcher conducted initial observations in one of the junior high schools in South Jakarta to identify female students with high mathematical spatial abilities as a basis for selecting further study subjects. From the results of these initial observations, one female student was found with prominent spatial performance and showed consistency in every problem-solving task. This finding is an interesting starting point to explore further, in order to understand the student's thought process and the factors that might support her excellence.

In mathematics learning, mathematical spatial ability ideally enables students to visualize and manipulate spatial shapes mentally (Makamure & Jojo, 2021). This ability is crucial in geometry problem solving and applications in the STEM (Science, Technology, Engineering, and Mathematics) fields (Herrera, Ordonez, & Ruiz-Loza, 2024). The Kurikulum Merdeka emphasizes the importance of developing spatial thinking skills in understanding the material of building space (Cholilah, 2023). This skill not only helps students in visualizing three-dimensional objects but also plays an important role in developing problem-solving and critical thinking abilities. In this context, understanding the cognitive processes that occur in students particularly female students with high spatial abilities becomes highly important. Therefore, knowing "how" and "why" a female student with high spatial ability thinks can provide insight for educators in designing more effective learning strategies.

Although various studies have addressed gender differences in mathematical spatial ability, there are still few studies that specifically explore how female students with high mathematical spatial ability think in solving math problems. In addition, there are still not many studies that identify internal and external factors, such as hobbies, learning systems, family or friend support, certain habits, and teacher teaching methods, that contribute to the development of mathematical spatial ability. Therefore, this study is expected to provide deeper insights into the thought processes of female student with high mathematical spatial ability and the factors that support their development.

METHODS

This research is qualitative research with a case study design that uses an interpretative approach. The interpretative approach is used because this research seeks to understand students' experiences as well as the mindsets and strategies they use in solving mathematical spatial problems (Lune & Berg, 2017). SMPN 68 Jakarta, a school with A accreditation and has complete facilities and infrastructure to support learning, was chosen as the research location because in this school the initial problem that became the basis of the research was found, namely to understand "how" and "why" a female student can have high mathematical spatial abilities.

The researcher plays a direct role as the main instrument in the process of data collection, analysis, and interpretation. Primary data was obtained through several supporting instruments, including: (1) three sets of mathematical spatial ability problems, each set of problem consists of two questions related to flat-sided space building material, these three sets of problems were given in three different meetings to the research subjects to see the consistency of students' mathematical spatial abilities over time; (2) semi-structured interview guidelines, the interview was conducted twice, the first interview focused on students' strategies or ways of solving the three sets of problems, while the second interview discussed students' experiences in the mathematics learning process; and (3) non-systematic observation sheets, which were used to record students' behavior, expressions, and strategies when working on problems at each meeting. Other than that, in analyzing the results of students' answers, the indicators of mathematical spatial ability, as in table 1, were used.

Table 1. Indicators of Mathematical Spatial Ability

No.	Aspect	Indicator
1.	Imaging	Students can model or describe the information obtained from the problem appropriately and correctly.
2.	Conceptualizing	Students can write the information given in the problem into mathematical concepts/models completely and correctly.
3.	Problem Solving	Students can solve or write solutions to problems in the problem from different/original points of view appropriately and correctly.
4.	Pattern Seeking	Students can find patterns/relationships to solve problems in the problem.

Source: Haas (2003)

The selection of research subjects began with an initial observation involving two ninth-grade classes consisting of 66 students (32 boys and 34 girls). The initial observation was conducted for two days by giving three questions based on flat-sided space building material that had been validated as an instrument to measure students' mathematical spatial abilities. The results of students' answers were then analyzed using indicators of mathematical spatial ability, and grouping was done to identify students with high mathematical spatial ability.

Table 2. Interval Grouping of Students' Mathematical Spatial Abilities

Category	Intervals of this Study
High	$s \geq 28{,}42$
Medium	$12{,}84 < s < 28{,}42$
Low	$s \leq 12{,}84$

Modified: Leni, Musdi, Arnawa, and Yerizon (2021)

Description:
s: Total score obtained by the student

Table 2 shows the score intervals obtained from the results of working on three questions at the initial observation stage by 66 students in class IX. Based on these intervals, several students from both classes were identified as having high mathematical spatial ability, as shown in table 3.

Table 3. Results of Initial Observation of Students with High Mathematical Spatial Ability

Subject	**Gender**	**Class**	**Score for Each Question**			**Total Score Max = 36**
			1	**2**	**3**	
M1	Male	IX A	12	11	11	34
M5	Male	IX A	9	11	9	29
M6	Male	IX A	12	8	10	30
M26	Male	IX D	10	9	11	30
M28	Male	IX D	10	10	10	30
M32	Male	IX D	8	11	10	29
F11	Female	IX A	10	7	12	29
F16	Female	IX A	12	11	12	35
F17	Female	IX A	12	12	12	36
F19	Female	IX D	8	11	12	31
F21	Female	IX D	12	12	11	35
F33	Female	IX D	9	12	12	33

(Maximum Score for Each Question = 12)

Based on the initial observation results in table 3, 12 out of 66 students were identified as having high mathematical spatial ability, with the composition of each class consisting of three male students and three female students. Of all these students, only one student, F17, a female student with high mathematical spatial ability, obtained the maximum score on each initial observation question.

The determination of the main subject in this study used a purposive sampling technique, by selecting F17, a female student with high mathematical spatial ability, who obtained the maximum score on each initial observation question, as the main focus in this study. To review the consistency of F17's mathematical spatial ability, three sets of problems were given to F17 along with five other students from the same class as a comparison. This comparison aimed to see if there was any variation in scores among the six students and to identify whether F17, as a female student, continued to show the highest performance/obtained the maximum total score in working on the three problem sets, or whether it was other female students or male students who obtained the maximum score.

The data analyzed in this study included the results of working on three sets of problems by female students with maximum scores, interview transcripts regarding students' experiences and strategies and thinking patterns in solving problems, as well as non-systematic observation notes during the working process and interview sessions. The instrument of the three problem sets has been validated through content validity by three mathematics education experts to ensure the suitability of the content with the indicators of mathematical spatial ability. To ensure the validity of the data, two triangulation techniques were used, namely time triangulation to assess the consistency of students' mathematical spatial abilities in working on three sets of problems at different times, as well as source triangulation to obtain accuracy of information from various perspectives, namely the results of working on three sets of problems, interview transcripts, observation notes, and documentation during the research.

RESULTS AND DISCUSSION

The results of this study focus on how and why a female student has high mathematical spatial ability. To test for consistency, the student was given three sets of problems (problem sets A, B, and C) at different times. As a comparison, five other students in the same class who were also identified as having high mathematical spatial ability, consisting of three male students and two female students, were given the same problem set. The scores obtained by the six students in working on the three problem sets can be seen in table 4.

Table 4. Results of Students' Work on Three Problem Sets

Subject	Gender	A		B		C		Total Score Max = 72
		1	2	1	2	1	2	
M1	Male	10	12	12	12	10	10	66
M5	Male	10	10	9	9	7	5	50
M6	Male	10	10	10	10	8	7	55
F11	Female	8	9	10	10	-	-	37
F16	Female	10	11	11	11	12	10	65
F17	Female	12	12	12	12	12	12	72

(Maximum Score for Each Question = 12)

In table 4 F17, or a female student with high mathematical spatial ability, showed consistency in obtaining the maximum score on each problem in all three problem sets. Meanwhile, the other five students showed variations in their results.

1. Problem Set A Solved by a Female Student (F17) with High Mathematical Spatial Ability

The problem set A in this study focuses on the concept of flat-sided spaces, particularly cubes. One of the problems in this set asks students to determine the total length of two threads of rope that tie a cardboard cube according to a predetermined trajectory pattern. To solve this problem, students need to visualize the position of the rope that binds the cardboard by understanding the points through which each thread of the rope passes. As shown in figure 1 shows the analysis of the results of F17's work in solving the problem in question.

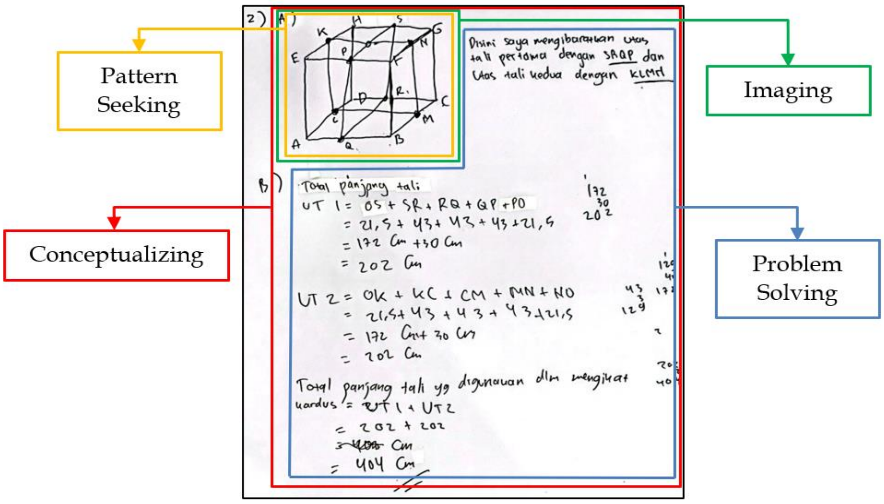

Figure 1. Result of Problem Number 2 in Problem Set A by F17

The problem solving done by F17 in figure 1, shows systematic results and is by the information and instructions contained in the problem. She started by drawing the ABCD.EFGH cube and the trajectory pattern of the two rope threads based on the points mentioned in the problem. F17 also added additional symbols to mark important points passed by the rope, making it easier to describe the total length of the rope needed. The interview results support how F17 worked on this problem.

I : How do you explain the trajectory of the first rope, which starts from point O and returns to point O?

F17 : Oh, if I just follow the instructions from the question, like for the trajectory of the first rope from O to S, which is what I assumed. Continue to R, the middle of C and D, then Q, the middle of A and B, then up to the middle of F and E, which is P. And in the question, it goes back to point O, so I just go to O.

I : Then, how did you strategize to calculate the length of the first rope and the second rope?

F17 : First, I've modeled it to make it easier to work with the first rope passing through the SRQP points and the second rope passing through the KLMN points. Then for the length of the first rope, I just added up all the lengths of the paths traversed by the rope, such as O to S is 21.5, then S to R is 43, R to Q is 43, Q to P is also 43, and P back to O is 21.5. SR, RQ, and QP are 43 long because they are the same as the length of the cube ribs, and OS and PO are 21.5 long because O is in the middle, so 43 is divided by 2. Likewise, to determine the length of the second rope. And at the end, I added 30 to each rope as instructed by the question.

From the interview, F17 explained that the main strategy she used in solving this problem was to understand and follow the instructions of the problem sequentially and ensure that each point through which the rope passed was identified. In determining the total length of the rope thread, F17 calculated the length of each rope path one by one before adding them up. F17 also stated that naming the traversal points helped avoid errors in calculating the length of the rope. Non-systematic observation notes of F17 while working on the problem set A also showed that in the early stages of working, F17 first focused on reading and understanding the question carefully before starting to work on the problem. In addition, during the interview session, F17 was given a blank paper to explain again how she determined the rope trajectory pattern. From her explanation, the rope trajectory pattern was drawn as shown in figure 2.

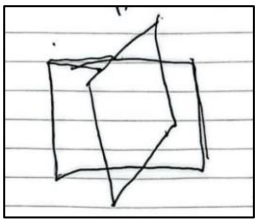

Figure 2. F17's Scribble Results in Re-explaining the Rope Trajectory Pattern on Blank Paper

In figure 2, F17 explained again how to determine the rope trajectory pattern on the cube by redrawing the rope trajectory on a blank paper without including a picture of the cube. The rope trajectory pattern depicted in this interview session was the same as the pattern made by F17 on the results of working on problem number 2 in problem set A. However, in this explanation, F17 only focused on the image of the rope trajectory pattern that bound the cardboard, without describing the visualization of the shape of the cardboard.

2. Problem Set B Solved by a Female Student with High Mathematical Spatial Ability

The problem set B focuses on flat-sided blocks. One of the problems in this problem set requires students to determine the volume of the remaining space after a block-shaped warehouse is built in it. To solve this problem, students need to understand the position of the warehouse in the empty cube-shaped room and use the formula for the volume of a cube and the volume of a block to find the answer. As in figure 3, which shows the analysis of the results of working on the problem referred to by F17.

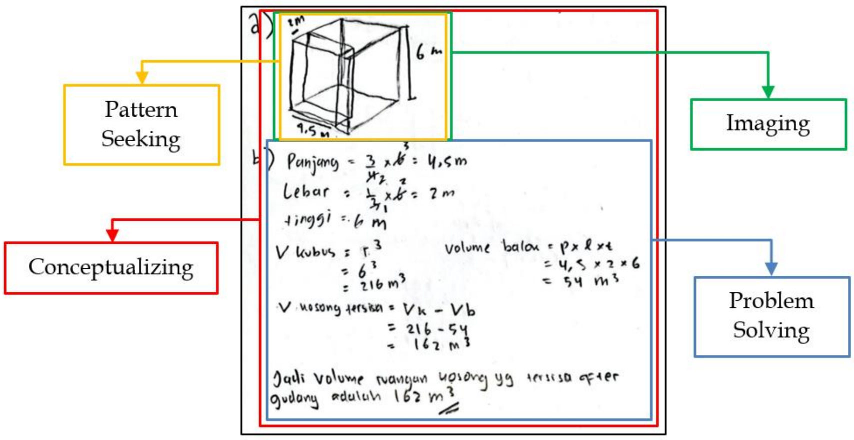

Figure 3. Result of Problem Number 2 in Problem Set B by F17

The results of F17's work in figure 3 show that she managed to understand the information given in the problem and illustrate the position of the warehouse in the empty room correctly. Her illustration shows the position of the warehouse attached to two walls and the floor, as stipulated in the problem. F17 followed a systematic calculation method, namely: calculating the initial volume of the empty room; then finding the volume of the warehouse; then subtracting the initial volume of the empty room from the volume of the warehouse. In addition, she was able to find and write down the length, width, and height of the warehouse. The interview results support how F17 worked on this problem.

I : How do you understand the position of the warehouse built in the empty room?

F17 : I used my imagination, so the problem explained that the empty room is a cube and the warehouse is a block. And it was also explained that the warehouse would be in the corner of the room, attached to the floor and roof, and also between two walls. So, I immediately made a cube as usual, and made the block inside smaller than the cube.

I : Then how do you understand the size of the warehouse in the problem?

F17 : The way I understand it, the problem states that the length of the cube rib is 6 meters. Then it is explained again that the length of the warehouse is 3/4 of 6, meaning 3/4 times 6. Then the width is 1/3 times 6 which is equal to 2. And the height, because it is attached to the base and roof, the height remains 6.

Based on the interview, when asked how to understand the position of the warehouse in an empty room, F17 explained that her first step was to read and understand the problem instructions thoroughly. After that, she began to imagine the position of the warehouse in an empty room based on the description of the problem before drawing it. In addition, the strategy used by F17 in determining the length, width and height of the warehouse was to multiply the known measurements in the problem with the length of the cube ribs. Non-systematic observation notes of F17 while working on the problem set B showed that in the early stages of the work, F17 first read and understood the problem carefully, then proceeded to describe the information contained in the problem.

Similar to the interview session for problem set A, in the interview session for problem set B F17 was also given a blank paper to explain again how she described the position of the warehouse in the empty room as shown in figure 4.

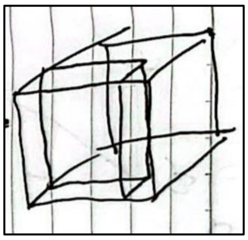

Figure 4. F17's Scribbles in Re-explaining the Illustration of Warehouse Position in an Empty Room on Blank Paper

In figure 4 shows the results of F17's scribbles on blank paper to explain again how she drew an illustration of the position of the warehouse in an empty room. and it can be seen that the results of the redrawing in the interview session, the illustration of the warehouse in an empty room drawn by F17 is the same as when she answered question number 2 in question problem set B, but it is a little messy because she did not slowly draw it or just wanted to explain it without looking.

3. Problem Set C Solved by a Female Student with High Mathematical Spatial Ability

The last problem set, problem set C focuses on the flat-sided space of prisms. One of the problems in this problem set requires students to find the division pattern of a rectangular prism-shaped birthday cake cut into 8 equal pieces. Each piece of cake is a right triangular prism. In addition, students are also asked to draw an illustration of 1/4 part of the cake taken, as well as determine the volume of the remaining cake after 1/4 part is taken. As in figure 5 which shows the analysis of the results of F17's answers in working on the problem

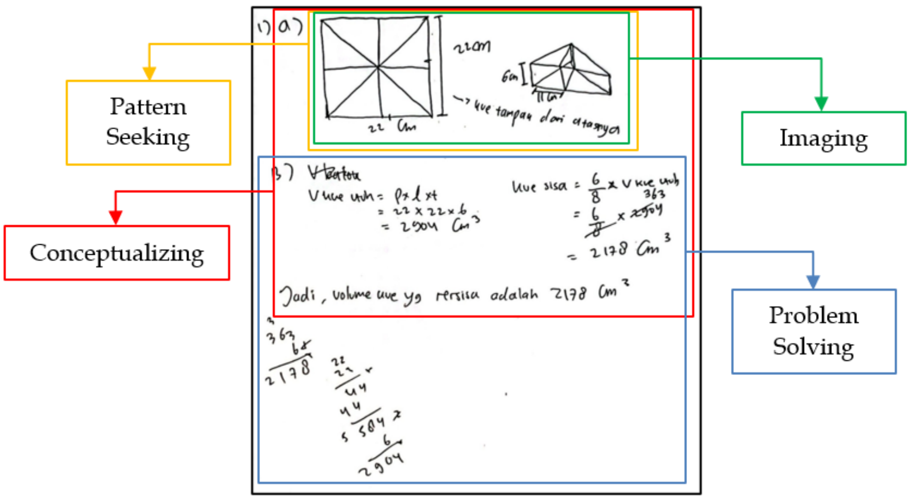

Figure 5. Result of Problem Number 1 in Problem Set C by F17

The result of the work is shown in figure 5 F17 was able to describe the information given in the problem well. She was able to find the pattern of dividing 8 equal parts of the cake and forming a right triangular prism by drawing the top view of the cake in the shape of a rectangular prism, then dividing the cake using the right division lines. In addition, she was also able to illustrate 1/4 of the cake by redrawing 2 of the 8 pieces of cake that had been cut. The interview results support how F17 worked on this problem.

I : How can you determine the pattern of cutting a cake that will produce 8 equal pieces and form a right triangular prism?

F17 : First it was explained that the shape of the cake is a rectangular prism, and in my brain, I divided it by making lines in the middle so that the cake from the top view is divided into 8 parts. Then I made sure whether there were 8 parts or not, or whether each part was equal or not. (When answering the question, F17 while redrawing the process of dividing the cake pattern).

I : Then, how do you take 1/4 of the cake that has been cut?

F17 : By drawing again next to it, so there are 8 parts, now I take 2 parts of the cake from those parts of the cake.

During the interview session, F17 explained how she found the pattern of dividing the cake into 8 equal parts. She said that she imagined a rectangular prism-shaped cake from the top view, then added the division lines that cut the cake into 8 equal parts. Non-systematic observation notes of F17 while working on the problem set C showed that F17 first skimmed the question, then immediately described the information contained in the problem, and was seen guessing the pattern of cutting the cake to get equal parts.

At the same time during the interview session, F17 also explained how she found the pattern of dividing the cake into 8 equal parts, as well as the illustration of 1/4 part of the cake by redrawing it on a blank paper as in figure 6.

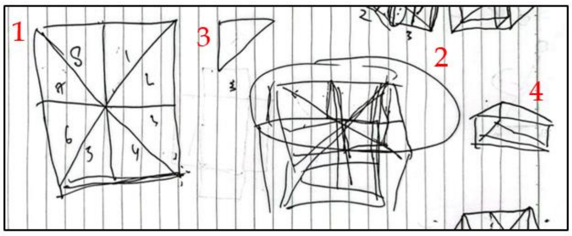

Figure 6. F17's Scribbles in Re-explaining the Pattern of Dividing the Cake into 8 Parts on Blank Paper

In figure 6, F17 re-explained during the interview session how she found the pattern of cutting the cake into 8 equal parts, and how she re-illustrated the 1/4 part of the cake pieces. In figure number 1, F17 explained the steps in determining the pattern of the pieces to obtain eight equal parts of the cake and form a right triangular prism; then in figure number 2 shows an illustration of a rectangular prism as a representation of a whole cake, where the pattern of the pieces is determined by looking at the top view of the cake; then, in figure number 3, F17 illustrates one piece of cake which from the top view forms a right triangular flat shape; and in figure number 4 is a redrawing of figure 3, namely one piece of cake in the form of a right triangular prism visualized as a whole.

4. Experience Interview with a Female Student with High Mathematical Spatial Ability

After completing the analysis of the results of the three problem sets, an in-depth interview was conducted with a female student with high mathematical spatial ability (F17). This interview was conducted online through the Zoom Meeting platform to explore information related to why F17 has high mathematical spatial abilities, especially in solving flat-sided space building problems.

The interview focused on exploring the internal and external factors that supported the development of F17's mathematical spatial ability. Internal factors included hobbies, cognitive strategies in learning, and habits outside of academics. While external factors include family support, the role of teachers, tutoring, social interaction with peers, and specific experiences. The following interview transcripts were selected because they have answers that are relevant enough to find out why F17 has high mathematical spatial abilities. The interview transcript is as follows.

I : What are your hobbies, and what subjects do you like at school?

F17 : My hobbies are drawing, coloring, and singing. And the subjects I like the most are science, math, and cultural arts.

I : How do you teach the material in class? Is there a way of teaching that you think is easy to understand?

F17 : Usually, what I often see in the teaching method is that my teacher explains the basic concepts of the material to be taught. So the math teacher who teaches me does not immediately give the formula, but explains how the formula exists.

I : How do you usually learn math? Is there a particular learning system you use?

F17 : There is, like at school, I focus on learning by paying attention to the teacher's explanation. And if at home, I do learning independently, usually by doing exercises. In addition, I also like to learn through video shows to understand some material.

I : When working on building space problems, are there any specific steps that you take?

F17 : There are no specific steps that I use, but the most obvious one is literacy/understanding the problem, like I will determine what is known about the problem. Then see what is asked in the problem.

I : Did you take any additional tutoring to understand math?

F17 : Yes, I attended two tutoring programs. First, there is general tutoring for science and math, and second, there is private tutoring for math and English.

I : Have you ever participated in a competition or activity related to math?

F17 : I have participated in the Olimpiade Sains Nasional (OSN) twice at the junior high school level, the first time when I was in 7th grade in math, and the second time when I was in 8th grade in science. But from both Olympiads, I haven't won any championships.

I : Do you have family or friends who often help you in learning math?

F17 : Of course, there is, my parents' family supports me in my learning by sending me to school and giving me additional tutoring. And my sister also often helps me in understanding material that is difficult for me to understand, or helps me with assignments from school. Likewise, friends, I usually have study groups with friends, especially my peer friends, and we both support each other in learning together to understand the material and learning at school.

I : Are there certain habits that you do at home? Like playing games or other things?

F17 : Besides studying, I usually play online games such as Minecraft or Block Blast (a kind of Tetris game).

Based on the results of working on three sets of mathematical spatial ability problems, interviews on the results of working on the problem sets, and non-systematic observations during working on the problem sets, it can be identified how a female student with high mathematical spatial ability solves problems related to flat-sided spaces. The female student showed the ability to understand and describe spatial information, such as describing spatial shapes, finding certain patterns referred to in the problem, and systematic solution strategies in answering questions on mathematical spatial ability problems. In addition, the interviews conducted revealed that an important step in solving mathematical spatial ability problems is to carefully read and understand the known and asked information in the problem. Non-systematic observations also showed that focus on the work and thoroughness in reading the questions played an important role in helping to solve problems related to mathematical spatial ability.

Some of the findings can be further analyzed through two main perspectives, namely internal factors and external factors, which together shape and strengthen F17's mathematical spatial abilities.

a. Internal factors affecting the high mathematical spatial ability of female student (F17)

Internal factors include F17's personal characteristics and learning strategies applied. From the interview, it is known that F17 has a hobby of drawing, where, according to Howard Gardner (in Putri & Widayanti, 2024), drawing is one of the activities related to visual-spatial intelligence and contributes to improving mathematical spatial abilities.

Female students with high mathematical spatial ability show an independent and consistent learning approach. The system or way of learning mathematics by female students with high mathematical spatial abilities applies the drill method, where these female students do learning independently by doing repeated exercises of math problems and also enjoy understanding math material by watching video shows. In line with research conducted by Purnamasari, Isman, Damayanti, and Ismah (2017), the use of the drill method can improve the understanding of junior high school students of flat-sided space building material.

Based on the observations of non-systematic observations and interviews conducted, female students with high mathematical spatial abilities have a fairly important first step when working on/solving flat-sided space building problems, namely literacy and fully understanding the context of the question from the problem. Hidayat and Wijayanti (2023) showed in their research that students who have mathematical literacy and a good understanding of a problem can design and determine strategies to get solutions to given problems, including problems in spatial mathematics.

In addition, female students with high mathematical spatial ability have the habit of playing online games such as Minecraft and Block Blast (a kind of Tetris game). Research conducted by Carbonell-Carrera, Jaeger, Saorin, Melian, and de la Torre-Cantero (2021) shows that the online game Minecraft can be an activity that can train skills and develops students' spatial abilities. And also, research conducted by Sudirman and Alghadari (2020) shows that Tetris online games can be one aspect of developing students' spatial abilities in learning mathematics.

b. External factors affecting the high mathematical spatial ability of female student (F17)

F17's mathematical spatial ability is also supported by various external factors. In the family environment, the parents of a female student with high mathematical spatial abilities facilitate the need to support learning, including in mathematics, such as sending her to school and also providing her with tutoring and private lessons. In addition, her sister also contributed to helping the female student in learning activities at home, such as explaining mathematical materials that were not understood at school, or assignments given by the school. The case study in Wijaya, Rahmadi, Chotimah, Jailani, and Wutsqa (2022) proves that the role of family support has an influence on student interest and achievement in learning mathematics.

Apart from family, support from peers is also an important factor. In the learning environment of female students with high mathematical spatial abilities, study friends also support them in understanding certain materials or lessons, such as making study groups or discussions with their classmates to study together to understand certain materials in math lessons. As in research conducted by Fitriani (2020) which proves that peer support has a positive influence on students' mathematics learning achievement.

In learning at school and outside of school, female students with high mathematical spatial abilities show systematic and quite productive learning in understanding mathematical concepts, especially flat-sided space building material. As in learning activities at school, the female student's mathematics teacher first emphasizes the explanation of basic concepts before presenting the material to be learned. As the literacy study conducted by Radiusman (2020) proves that students who are taught to understand the basic concepts of mathematics can solve mathematical problems, including problems related to mathematical spatial abilities.

Outside of school learning, the female student participates in tutoring classes and also has additional private lessons on mathematics, which indicates that in mathematics lessons, the female student is actively involved in deepening and getting additional explanations, including the material on building spaces. Sipayung and Sipayung (2025) conducted a study that proved that private tutoring/additional tutoring has a positive influence on improving the math skills of junior high school students.

In addition, the experience that female students with high mathematical spatial abilities have gone through is the Olimpiade Sains Nasional (OSN) in mathematics during grade 7. Research conducted by Damanik and Ratu (2021) describes that students with high mathematical abilities can complete the stages of solving problems with geometry content, including building spaces.

5. Implications for Gender Neutral Learning Approaches

The finding of a female student (F17) demonstrating high mathematical spatial ability provides an important foundation for designing gender-neutral learning approaches. This research proves that spatial ability is not dominated by one particular gender, and that even female students can show superior performance in spatial skills. Therefore, educators need to design learning strategies that are not gender biased, for example, by involving various visual media, manipulative-based activities, direct exploration of spatial objects, and equal opportunities for all students to express and practice their mathematical spatial abilities. Thus, mathematics learning can become more inclusive, empowering, and fair for all students.

CONCLUSION

Female students with high mathematical spatial ability show consistent, systematic, and imagination-based problem-solving patterns. This student is able to understand the problem instructions thoroughly, describe the shapes of the space appropriately, and develop a gradual solution strategy. The mathematical spatial ability of this female student is not only formed from the experience of solving problems, but also supported by various factors. From internal factors, female students show an independent learning approach with the drill method, have a hobby of drawing, and play Minecraft and Block Blast games that can scientifically develop spatial skills. Meanwhile, external factors included family support, especially her parents and older sister, who had a positive influence on her learning process. In addition, the presence of study buddies who encouraged collaboration and discussion also created a supportive learning atmosphere. The learning system from her mathematics teacher that emphasized understanding basic concepts, her involvement in tutoring and private lessons, and her experience participating in the Olimpiade Sains

Nasional (OSN) in mathematics also strengthened her mathematical spatial abilities.

This study shows that high mathematical spatial abilities in female student are formed through a combination of effective learning strategies, environmental support, and non-academic habits that train their mathematical spatial abilities. This research can serve as a basis for designing mathematics learning approaches for students that are more contextual and based on strengthening mathematical spatial abilities. In addition, this study has limitations on the number and variety of subject characteristics, because it only involves one female student with high mathematical spatial ability. Therefore, it is suggested that future research can involve more diverse subjects in order to gain a broader understanding of the pattern of mathematical spatial ability.

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