Advances in Social Science, Education and Humanities Research, volume 556
Proceedings of the 2nd Annual Conference on Education and Social Science (ACCESS 2020)

Spatial Abilities of Students Who Have Dominant Mathematical Logical Intelligence in Terms of Gender Differences

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***Abstract*— This research was conducted at a high school located in Palu City, Central Sulawesi, Indonesia. This study aims to obtain a description of the spatial abilities of male students and female students who have dominant mathematical logical intelligence. The subjects of this study consisted of a male student (S1) and a female student (S2) of class X high school who had dominant mathematical logical intelligence. Two students selected as research subjects were netted through a multiple intelligence test given to 29 students in class X MIA 5. This type of research is a qualitative descriptive study. The spatial ability data of the two research subjects was obtained through geometric questions and unstructured interviews. In this study, researchers described students' spatial abilities based on 5 elements of spatial intelligence proposed by Maier (1998) which consisted of: (1) spatial perception on SG1-01 and SG2-01, (2) spatial visualization on SG1-02 and SG2-02, (3) mental rotation on SG1-03A and SG2-03A, (4) spatial relations on SG1-03B and SG2-03B, and (5) spatial orientation on SG1-04 and SG2-04. The results showed, in solving SG1: (1) S1 was more dominant in using his spatial ability in solving SG1 01, SG1 03A, SG1 03B, and SG1 04, and integrating spatial ability and mathematical logical ability in solving SG1 02; (2) S2 was more dominant in using her spatial ability in solving SG1 01 and SG1 04, integrating spatial ability and mathematical logical ability in solving SG1 02, and more dominantly uses mathematical logical ability in solving SG1 03A and SG1 03B.**

Keywords*— *Spatial Abilities, Mathematical Logical Intelligence, Sex Differences

I. INTRODUCTION

Mathematics is a branch of science that has an important role in advancing science and technology. There are 5 content standards in mathematics, namely: numbers and their operations, algebra, geometry, measurement, probability, and data analysis [1]. In this study, researchers chose geometry because of geometry is a mathematical field that provides great potential for developing a subject. Also, the visual nature of geometry and its relation to design and art can provide interesting opportunities for studying geometry [2].

To master geometry, students' needs intelligence to understand images, so they can solve geometry problems well. This intelligence is one of the bits of intelligence that exist in multiple intelligences which is called spatial intelligence. Spatial visual intelligence shows a person's ability to understand more deeply the relationship between objects and space [3]. Apart from spatial intelligence, students also need intelligence in analyzing the information used to solve geometric problems. Students must be able to find links between existing information to answer a geometric problem, this ability can be done well by people who have mathematical logical intelligence [4].

Every student has a different intelligence. The differences are related to genders caused by biological, physiological, and psychological factors. Maccoby & Jacklyn stated that men and women have different abilities, namely: women have higher verbal abilities than men and men are superior in math skills [5]. This difference indicates a difference in the spatial abilities of male students and female students who have dominant mathematical logical intelligence. This was the underlies researchers to study the Spatial Abilities of Students who have Dominant Logical-Mathematical Intelligence in Terms of Sex Differences.

In this study, researchers described students spatial abilities based on 5 elements of spatial intelligence which consisted of: (1) spatial perception; (2) spatial visualization; (3) mental rotation; (4) spatial relations; and (5) spatial orientation [6]. Students need these elements of intelligence to study and solve geometric problems, therefore spatial intelligence is very important for students so that teachers are expected to help students develop their spatial intelligence. This is in line with the research results of Safranj & Zivlak which state that multiple intelligence implies that teachers can pay attention to all types of intelligence, design syllabus by taking various benefits from teaching and learning activities to encourage the development of intelligence [7]. Conversely, if the teacher does not know the students 'spatial intelligence, the teacher will not get a description of the students' spatial abilities so that the planned learning cannot accommodate the situation of each student, especially in studying geometry material. The teacher can get an overview of the student's spatial abilities by solving geometric problems.

II. METHOD

This is a qualitative descriptive study. The spatial ability data of the two research subjects were obtained through geometric questions and unstructured interviews. The geometry problem used a geometry problem in the form of a description. This research was conducted at at a public

high school in the city of Palu, which is located in Palu City, Central Sulawesi, Indonesia. The subjects of this study consisted of a male student (S1) and a female student (S2) of class X who had dominant mathematical logical intelligence.

Two students selected as research subjects were netted through a multiple intelligence test given to all students in class X MIA 5. This test consists of 80 statements, which are divided into 10 statements for each type of multiple intelligence. Grouping of subjects who have dominant mathematical logical intelligence is done by adding up the scores of each multiple intelligence test. The selection of male students and female students who have dominant mathematical logical intelligence is carried out by taking male students and female students who obtain the highest mathematical logical intelligence score on multiple intelligence tests. The results of the multiple intelligence tests of the research subject are presented in Table I.

TABLE I. RESULTS OF MULTIPLE INTELLIGENCE TESTS

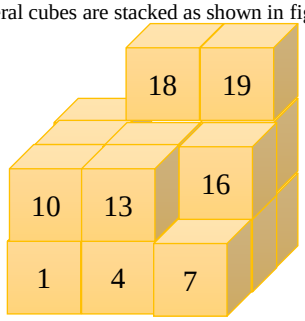
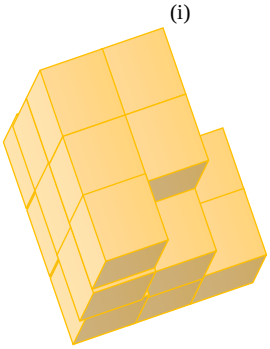
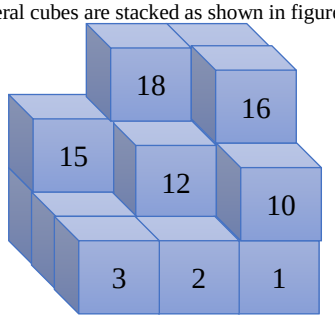
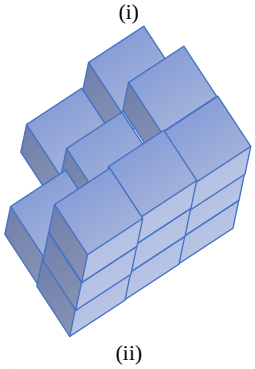
No.	Students	M/P	Multiple Intelligence Score								Information
			01	02	03	04	05	06	07	08	
1.	MN	M	39	43	35	29	41	40	30	32	S1
2.	MS	P	39	46	39	35	36	35	41	43	S2

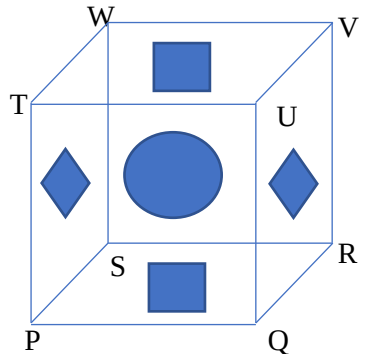
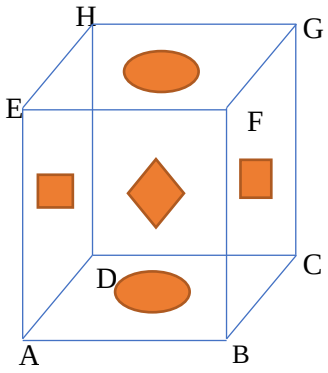
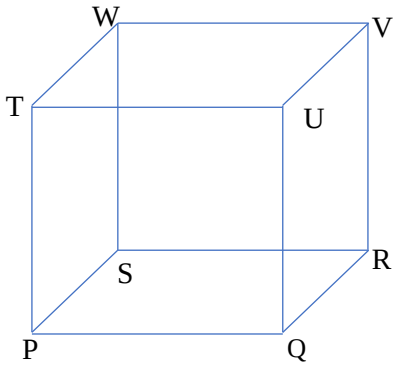
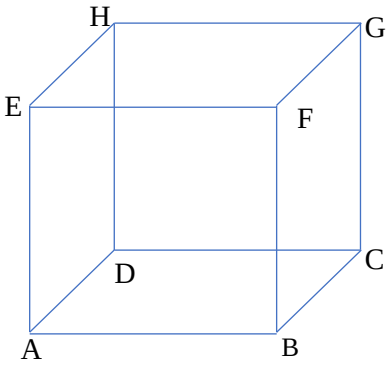
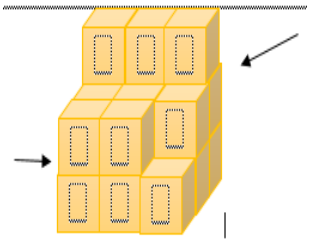
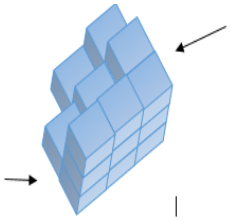
Data on the spatial ability of the research subjects were obtained through the completion of the subjects geometry questions and interviews which were then analyzed qualitatively based on data analysis techniques according to [8], which is carried out interactively through a data condensation, data display, drawing and verifying conclusions.

III. RESULT AND DISCUSSION

The credibility test of the data of the two subjects with time triangulation shows that the data for both solving the First Geometry Problem (SG1) and the Second Geometry Problem (SG2) are credible so that the data analyzed and discussed are only the data of the two subjects in completing SG1.

TABLE II. SG1 AND SG2

No	First Geometry Problem	Second Geometry Problem
1.	Several cubes are stacked as shown in figures (i) and (ii).  (i)  (ii) Is the stack of cubes in Figure (ii) the same as the pile of cubes in Figure (i)? give your reasons. If the same, write the number of each cube and determine the horizontal position and vertical position for the stack of cubes in figure (ii) according to figure (i).	Several cubes are stacked as shown in figures (i) and (ii).  (i)  (ii) Is the stack of cubes in Figure (ii) the same as the pile of cubes in Figure (i)? give your reasons. If the same, write the number of each cube and determine the horizontal position and vertical position for the stack of cubes in figure (ii) according to figure (i).
2.	Draw all possible nets of the cube below if each side facing each other on the cube has the same image, with the TUVW plane as the cover and the PQRS plane as the base.	Draw all possible nets of the cube below if each side facing each other on the cube has the same figure, with the EFGH plane as the cover and the ABCD plane as the base.

No	First Geometry Problem	Second Geometry Problem
		
3.	Examine the PQRS.TUVW cube below  If the cube is rotated 90o counterclockwise to the axis of rotation on the edge of the RV, then: a. Draw the cube as it rotates, and write down the corner points. b. Find all the line segments that intersect the PS line.	Examine the ABCD.EFGH cube below  If the cube is rotated 90o forward with the axis of rotation on the edge AB, then: a. Draw the cube as it rotates, and write down the corner points. b. Find all the line segments that intersect the line EF.
4.	Look at the image below.  (iii) Draw a stack of cubes from the image (iii) when viewed from the left side and the back side.	Look at the image below.  (iii) Draw a stack of cubes from the image (iii) when viewed from the bottom and the right side.

A. S1 in Completing SG1 01

S1 solves problems related to spatial perception by determining the number of the stack of cubes before being manipulated and determining the number of the stack of cubes that are located in the horizontal position and the vertical position after being manipulated. S1 determines the number of the stack of cubes before being manipulated by counting the cubes in Figure (i) sequentially from front to back based on the number of the cube shown and determines the number of cubes for the horizontal position and vertical position in Figure (i), which can be used to determine the horizontal position and the vertical position of the stack of cubes in figure (ii). S1 can determine the horizontal position and vertical position from the figure (i) and figure (ii) because S1 knows the meaning of horizontal position and vertical position.

Furthermore, S1 knows the change in the position of the stack of cubes after being manipulated by saying that the stack of cubes in figure (i) and figure (ii) is the same because the number of cubes is 19 cubes each and the direction of the stack of cubes is slightly turned to the right. Besides, S1 also knows the change in the position of the stack of cubes after being manipulated by counting the number of cubes in each image and imagining the position of the stack of cubes that is not visible.

Then, S1 determines the stack number of the cubes which is located in the horizontal position and the vertical position after being manipulated. S1 determines the number of the stack of cubes that are located in a horizontal position

by mentioning the horizontal position of the stack of cubes in figure (ii) which corresponds to figure (i). S1 determines the number of the stack of cubes in the first row (bottom row) in a horizontal position by adjusting the number of the stack of cubes and paying attention to the position of the stack of cubes in figure (i) and figure (ii). Besides, S1 also knows the number and position of the invisible pile of the lowest row cubes by imagining the invisible cube number and counting the cubes sequentially from top to bottom. S1 determines the number of the stack of cubes in the second row (middle row) by looking at the stack of cubes directly above the stack of cubes in the first row and imagining the number of the stack of cubes that is not visible on the second row. S1 determines the number of the stack of cubes in the third row (top row) by looking at the stack of cubes directly above the stack of cubes in the second row and can determine the stack number of cubes directly because the stack of cubes on the top row in figure (ii) is the same as the stack the front cube in figure (i).

S1 determines the number of the stack of cubes that are located in a vertical position by mentioning the vertical position of the stack of cubes in figure (ii). S1 determines the number of the stack of cubes in the first column (leftmost column) in a vertical position by looking at the position of the stack of cubes vertically and matching the front of the stack of cubes in figure (i) with the top of the pile of cubes in figure (ii). S1 determines the number of the stack of cubes in the second column (middle column) by counting the cubes from top to bottom and imagining the invisible cube in the second column. S1 determines the number of the stack of cubes in the third column (rightmost row) by looking at the stack of cubes that is right next to the stack of cubes in the second column.

Based on the description above, S1 completed SG1 01 using his spatial perception ability and mathematical logical intelligence. S1 uses its spatial perception ability by using the number of cubes that have been provided to calculate the number of the stack of cubes sequentially and imagining the position and number of the cubes that are not visible from Figure (i) and Figure (ii). Besides, S1 also uses mathematical logical intelligence to compare the information on SG1 01 with knowledge of horizontal and vertical positions.

B. S1 in Completing SG1 02

S1 solves problems related to spatial visualization by providing an overview of the parts of the cube that have changed or displaced. S1 provides an overview of the parts of the cube that experience change or displacement by determining the PQRS.TUVW cube net. S1 determines the PQRS.TUVW cube network by imagining the PQRS.TUVW cube is opened to form a grid of cubes. Next, S1 first draws all known cube nets, then continues by determining the location of the square, rhombus, and circle images on the cube nets. S1 determines the location of the square, rhombus, and circle images on the cube net by determining the location of the image on the base and closing the cube first, then the left and right sides of the cube, and the front and back of the cube.

Based on the description above, S1 completed SG1 02 by using his spatial visualization abilities to create cube nets by imagining the PQRS.TUVW cube opened and imagining the PQRS.TUVW cube net folded back until it becomes a complete cube. In addition, S1 also integrates spatial visualization skills and mathematical logical intelligence in determining the location of square, rhombus, and circle images in the PQRS.TUVW cube net by first determining the image on the base and lid of the cube, then looking at the relationship between the grids cube nets with each other.

C. S1 in Completing SG1 03A

S1 solves the mental rotation problems by rotating the PQRS.TUVW cube correctly. S1 knows the change of the PQRS.TUVW cube after turning it by mentioning the change of the cube to be the SPQR.WTUV cube. Next, S1 rotates the cube 90° counterclockwise by rotating the PQRS.TUVW cube right-hand side. S1 also explains that there is no difference between the cube before and after it is rotated, and S1 correctly mentions the part of the cube that experiences a displacement after rotating by mentioning the position displacement of the corner points on the PQRS.TUVW cube.

Based on the description above, S1 completed SG1 03A using the ability of mental rotation and mathematical logical intelligence in rotating the cube 90° counterclockwise by imagining rotating the PQRS.TUVW cube right-hand side based on the knowledge he has about right angles elbow and clockwise direction. Furthermore, S1 uses his mind's rotation ability in determining the position displacement of corner points on the PQRS.TUVW cube by paying attention to the displacement of the corner points on the PQRS.TUVW cube before and after being rotated.

D. S1 in Completing SG1 03B

S1 solves problems related to spatial relations by determining the parts of the PQRS.TUVW cube and their relationship between one part and another. This is known because S1 can correctly name all line segments that intersect the PS line and their points of intersection based on the figure for part A. S1 can list all line segments that intersect the PS line because S1 knows what the line intersects. In addition, S1 also explains that there is no difference in the line segment that intersects the PS line on the PQRS.TUVW cube before and after it is turned.

Based on the description above, S1 completes SG1 03B using its spatial relation ability in determining all line segments that intersect the PS line by observing the image in number 3A and paying attention to the PS line segment and its points of intersection. Also, S1 uses mathematical logical intelligence in determining the segment of the line that intersects the PS line by using his knowledge of the meaning of the intersecting line.

E. S1 in Completing SG1 04

S1 solves problems related to spatial orientation by determining the shape of the image (iii) when viewed from the left and the back. This is known because S1 determines the shape of Figure (iii) when viewed from the left side by paying attention to the vertical position of the leftmost column in Figure (iii). Next, S1 determines the shape of Figure (iii) when viewed from the backside by observing

from the front the horizontal position of the top line in Figure (iii).

Based on the description above, S1 completed SG1 04 using its spatial orientation ability to determine the image (iii) when viewed from the left and the backside by imagining and counting the cubes in figure (iii) sequentially. Besides, S1 also uses its spatial orientation capabilities in determining the shape of the figure (iii) when viewed from the left side by paying attention and imagining the vertical position of the leftmost column of cubes in figure (iii) and S1 determining the shape of the figure (iii) when viewed from the backside by observing and imagining from the front the horizontal position of the stack of cubes on the top row in figure (iii).

F. S2 in Completing SG1 01

S2 solves problems related to spatial perception by determining the number of the stack of cubes before being manipulated and determining the number of the stack of cubes that are in the horizontal position and the vertical position after being manipulated. S2 determines the number of the stack of cubes in figure (i) by paying attention to the number of available cubes, then imagining the invisible cube, and counting the number of the cube sequentially from front to back. Also, S2 knows the meaning of horizontal position and vertical position.

Furthermore, S2 knows the change in the position of the pile of cubes after being manipulated by saying that the stack of cubes in figure (ii) and figure (i) is the same because the number of cubes is 19 each and the position of the stack of cubes in figure (ii) is rotated slightly to the right. S2 knows the changes in the position of the stack of cubes after being manipulated by counting and imagining the number of visible and invisible cubes from each image.

Then, S2 determines the stack number of the cubes which is located in the horizontal position and the vertical position after being manipulated. S2 determines the number of the stack of cubes that are located in a horizontal position by mentioning the horizontal position of the stack of cubes in figure (ii) which corresponds to figure (i). Before matching the number of the stack of cubes in figure (ii) and figure (i), S2 first determines all the numbers of the cubes in figure (i) by paying attention to the number of cubes that are visible and imagining the number of cubes that are not visible and calculating the number of cubes from front to back. S2 determines the number of the stack of cubes in the first row (bottom row) in a horizontal position by adjusting the stack number of cubes in figure (i) to figure (ii). Besides, S2 also determines the number of the stack of cubes in the lowest row that is not visible by imagining and counting the cubes sequentially from top to bottom. S2 determines the number of the stack of cubes in the second row (middle row) by paying attention to the stack of cubes that is horizontal just above the stack of cubes in the first row and imagining the number of cubes that are not visible on the second row. S2 determines the number of the stack of cubes in the third row (top row) by looking at the stack of cubes directly above the stack of cubes in the second row.

S2 determines the number of the stack of cubes located in a vertical position by mentioning the vertical position of the stack of cubes in figure (ii). S2 determines the stack number of the first column (leftmost column) in a vertical position by imagining the y-axis on the Cartesian diagram and can directly determine the stack number of the cubes. S2 determines the number of the stack of cubes in the second column (middle column) by imagining the invisible cubes in the second column and calculating the cubes from top to bottom. S2 determines the number of the stack of cubes in the third column (rightmost row) by looking at the pile of cubes that is right next to the stack of cubes in the second column.

Based on the description above, S2 solved SG1 01 using its spatial perception ability by calculating the number of the stack of cubes in sequence according to the number of the stack of cubes seen and imagining the position and number of the stack of cubes that are not visible from the figure (i) and figure (ii). In addition, S2 also uses mathematical logical intelligence in determining the number of the stack of cubes in the horizontal position and the vertical position of the figure (i) and figure (ii), using his knowledge of the meaning of horizontal position and vertical position.

G. S2 in Completing SG1 02

S2 solves problems related to spatial visualization by providing an overview of the parts of the cube that experience change or displacement. S2 provides an overview of the parts of the cube that experience change or displacement by determining the PQRS.TUVW cube net. S2 determines the PQRS.TUVW cube network by observing and counting the number of fields in the cube and imagining the PQRS.TUVW cube is opened to form a cube net. Next, S2 determines the location of the square, rhombus, and circle images on the PQRS.TUVW cube net by imagining the cube webs folded back until they become a complete cube then determines the location of the image on the base and closes the cube first, then the left and right sides of the cube, and the front and back of the cube.

Based on the description above, S2 completed SG1 02 using her spatial visualization abilities to create cube nets by imagining the PQRS.TUVW cube opened and imagining the PQRS.TUVW cube net folded back until it becomes a complete cube. Furthermore, S2 integrates spatial visualization capabilities and mathematical logical intelligence to determine the location of square, rhombus, and circle images by determining the position of the image on the base and lid of the cube first, then the left and right sides of the cube, and the front and back of the cube by paying attention to the relationship between the location of the image on one cube net and another.

H. S2 in Completing SG1 03A

S2 solves the mental rotation problems by rotating the PQRS.TUVW cube accurately. S2 knows the change in the PQRS.TUVW cube after rotating by saying that there is a displacement at its corner points. Next, S2 rotates the PQRS.TUVW cube 90 ° counterclockwise by turning the PQRS.TUVW cube to the left by 90o. S2 also correctly mentions the part of the cube that experiences a displacement after rotating by mentioning the displacement of the points of the PQRS.TUVW cube.

Based on the description above, S2 completed SG1 03A using his mental rotation ability and mathematical logical

intelligence in rotating the cube 90 ° counterclockwise by imagining rotating the PQRS.TUVW cube to the left by 90o based on his knowledge of the direction of rotation on the clockwork. Then, S2 uses its mathematical logical intelligence to determine the displacement of the corner points on the PQRS.TUVW cube by identifying the relationship between the displacement of the cube's edges and its vertices.

I. S2 in Completing SG1 03B

S2 solves problems related to spatial relations by determining the parts of the PQRS.TUVW cube and their relationship between one part and another. This is known because S2 can correctly name all segments that intersect the PS line and their points of intersection. In addition, S2 also explained that there is no difference between the line segments that intersect the PS line on the PQRS.TUVW cube before and after turning it.

Based on the description above, S2 resolves SG1 03B using her spatial relation abilities by first rotating the PQRS.TUVW cube 90 ° counterclockwise and observing the PS line segment and its points of intersection to determine the line segments that intersect the PS line. Besides, S2 also uses mathematical logical intelligence by using its knowledge of the meaning of intersecting lines to determine the segments of the line that intersect the PS line.

J. S2 in Completing SG1 04

S2 solves problems related to spatial orientation by determining the shape of the image (iii) when viewed from the left side and the backside. This is known because S2 determines the shape of the figure (iii) when viewed from the left side by observing the horizontal position of the stack of cubes in the figure (iii). Next, S2 determines the shape of (iii) when viewed from the back by observing the front of the stack of cubes (iii).

Based on the description above, S2 solved SG1 04 using her spatial orientation ability by imagining and calculating the visible and invisible cubes from the figure (iii). Besides, S2 also uses the ability of its spatial orientation in determining the shape of the figure (iii) when viewed from the left side by observing and imagining the horizontal position of the leftmost column of cubes in figure (iii) and determining the shape of the figure (iii) when viewed from the back side by observing and imagining the front of the stack of cubes in figure (iii).

K. Spatial Abilities of Male Students (S1) and Female Students (S2) Who Have Dominant Mathematical Intelligence in Completing SG1

Boys and girls who have mathematically dominant logical intelligence solve the first geometry problems using their spatial abilities and mathematical logical intelligence. The answers given by male and female students in solving the first geometry problem were almost all correct and almost the same. This indicates that students who have mathematically dominant logical intelligence also have the good spatial ability. This is in line with research conducted by [9]which shows that spatial ability and mathematical logical intelligence do not contribute significantly to mathematical problem-solving abilities, it's just that there is a relationship between spatial ability and mathematical logical intelligence of 60.9%. The fundamental differences are how to solve problems, use of spatial abilities, and use mathematical logical intelligence which shows the profile of spatial abilities students' in solving geometry problem based on gender differences.

Male students who have mathematically dominant logical intelligence are more dominant in using their spatial abilities in completing SG1 01, SG1 03A, SG1 03B, and SG1 04 and integrate their spatial abilities and mathematical logical intelligence in solving SG1 02. Meanwhile, female students who have dominant mathematical logical intelligence more dominant in using her spatial ability in solving SG1 01 and SG1 04, integrating spatial ability and mathematical logical intelligence in solving SG1 02, and more dominantly using mathematical logical intelligence in solving SG1 03A and SG1 03B.

Based on the description above, it can be concluded that male students who have dominant mathematical logical intelligence are more dominant in using abilities in their spatial intelligence compared to female students who have dominant mathematical logical intelligence. Many studies conclude that men's spatial ability is better than women's although some conclude the opposite and some conclude that there is no difference between the two. However, in this study, researchers cannot conclude that male spatial ability is better than female spatial ability, but it seems clear that there is a difference between the two in terms of their use.

Male students predominantly use their spatial ability, possibly due to several things, one of which is from a biological perspective that focuses on hormones and brain development. According to Hampson, Rovelt, & Altman, women who have high levels of androgen hormones during adolescence have better spatial intelligence than other women [10]. Meanwhile, according to Hier & Crowley, male adolescents who have lower levels of androgens have lower spatial intelligence than other men [10].

Regarding the brain, humans have two hemispheres, namely the right hemisphere associated with spatial-visual intelligence and the left hemisphere associated with language and verbal skills. According to de Lacoste, Hovarth & Woodward, the right brain in men is more developed and larger than women, this is what causes men to use their spatial intelligence more dominantly than women [10].

IV. CONCLUSION

Male students who have dominant mathematical logical intelligence (S1) are more dominant in using their spatial abilities in solving problems related to spatial perception, mental rotation, spatial relations, and spatial orientation, as well as integrating spatial abilities and mathematical logical intelligence in solving problems related to spatial visualization.

Female students who have dominant mathematical logical intelligence (S2) are more dominant in using their spatial abilities in solving problems related to spatial perception and spatial orientation, integrating their spatial abilities and mathematical logical intelligence in solving related problems with spatial visualization, and more

dominantly using mathematical logical intelligence in solving problems related to mental rotation and spatial relations.

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