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ANALYSIS OF MATHEMATICAL SPATIAL ABILITY REVIEWED FROM GENDER DIFFERENCES IN MADRASAH ALIYAH STUDENTS

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Abstract

Mathematical spatial ability is one of the important things in learning mathematics. This ability will make it easier for students in the learning process on Geometry material. This research aims to describe the mathematical spatial abilities of MAN 4 Aceh Besar students in terms of gender differences in solving distance problems between cube elements in the third dimension. This research uses a qualitative approach with descriptive research type. The research subjects were 2 male students and 2 female students based on mathematical spatial abilities. Data collection techniques were carried out by writing spatial ability tests and conducting interviews. Data analysis techniques by reducing data, presenting data, and making conclusions. The data validity checking technique uses source triangulation. The results of the research show that male and female students can both go through the stages of mathematical spatial indicators well. It can be concluded that the mathematical spatial abilities of male and female students are both good, but there are differences between the two in solving three-dimensional problems, female students are more thorough and more complete and take longer than male students who solve problems practically, briefly and fast.

1. Introduction

Mathematics as one of the sciences that plays an important role in building mindsets and developing the quality of human resources. Mathematics consists of several study topics such as algebra, calculus, logic, trigonometry, geometry and others which are selected based on or oriented to educational interests and in line with the development of science and technology and become part of the mathematics curriculum in elementary and secondary schools. As quoted by Sudirman (2020), NCTM (National Council of Teachers of Mathematics) has set 5 (five) content standards in mathematics, namely numbers and their operations, problem solving, geometry, measurement and probability, and data analysis. According to Alders, C.J. as quoted by Damayanti, et al. (2021), Geometry is a branch of mathematics that studies points, lines, planes, spatial objects, along with their properties, dimensions, and relationships to each other. From a psychological perspective, geometry is an abstract representation of visual and spatial experiences such as planes, patterns, measurements and mapping. Meanwhile, from a mathematical perspective, geometry provides various approaches to problem solving, such as images, diagrams, coordinate systems, vectors, and transformations (Samsumarlin, 2017). This makes

geometry learning one of the most important things in mathematics learning because geometry supports many topics that play an important role in solving mathematical problems. According to Budiarto (2000), the purpose of geometry learning is to develop logical thinking skills, develop spatial intuition about the real world, provide the knowledge needed for advanced mathematics, and teach how to read and interpret mathematical arguments. Behind geometry learning, there are several aspects of geometric concepts, namely the use of visualization, spatial reasoning, and modeling, so that spatial skills are needed to learn geometry, especially in its application in life (Sudirman, 2020). Thus, it can be said that the purpose of geometry learning is to develop logical, spatial thinking skills, instill knowledge to support other materials, solve problems in life, communicate and reason mathematically. Learning geometry involves thinking activities related to the movement of objects and space known as spatial abilities. So talking about geometry cannot be separated from mathematical spatial abilities. This mathematical spatial ability is a concern in mathematics learning, because this ability is very much needed in dealing with problems related to geometric building patterns in real contexts.

Spatial ability is one of the nine theories of multiple intelligences consisting of linguistic intelligence, logical mathematical and numerical intelligence, spatial intelligence, kinesthetic intelligence, musical intelligence, interpersonal intelligence, intrapersonal intelligence, intelligence about nature, and existential intelligence (Selviana, 2021). Based on these nine intelligences, spatial ability plays an important role in learning geometry. Spatial ability is the ability to understand the spatial world accurately. In studying geometry, students are indeed required to have spatial skills. This ability is related to color, line, shape, shape, space, and their relationships. This includes the ability to imagine spatial concepts, draw spatial ideas and accurately explain spatial arrangements. Armstrong, quoted by Sefriana Dyah (2018), said that someone with good spatial intelligence can easily visualize objects in three-dimensional space, accurately identify the relationship of objects in space, correctly perceive objects in the surrounding space, and see them from all angles.

NCTM, as quoted by Kamila Ismi (2021), states that spatial thinking is a combination of cognitive skills consisting of spatial concepts, representation skills, and thought processes. Spatial ability is also the ability to reason through changes in mental

images, abilities related to everyday life to be able to imagine space. According to Lohman in Hibatullah (2020) there are 3 (three) main factors in mathematical spatial ability, namely representing, manipulating, rotating, or reversing objects without referring to oneself); Spatial Orientation (students' ability not to be confused by changes in orientation); and spatial relationships (the ability to determine the relationship of an object to another object. Sugiarni (2018) states that spatial ability is the ability to imagine, illustrate, assess, determine, construct, present and find information from visual stimuli in a spatial context. This spatial ability is very important for students in solving geometry problems. The better the students' mathematical spatial abilities, the more it will help students in understanding the theory in mathematics lessons. Students find it easier to communicate mathematical ideas into mathematical symbols which results in students being able to optimally solve mathematical problems in the form of images.

Forms of interaction based on mathematical spatial ability, Hafiziani (2017) stated that: 1) observing geometric objects, both solid and flat shapes, and distinguishing them based on their properties; 2) producing information that cannot be observed with the naked eye, for example determining distance, height, area and volume; 3) representing solid objects in two dimensions; 4) interpreting two-dimensional representations of solid objects. These forms of interaction are needed to get an idea of what skills are needed to improve mathematical spatial ability. Furthermore, Hafiziani (2017) stated that the characteristics of someone who is said to have good mathematical spatial ability are: 1) always coming up with interesting ideas; 2) enjoying organizing and arranging space; 3) creating artwork with different media; 4) using graphic organizers is very helpful in learning and remembering; 5) feeling satisfied when showing artistic abilities; 6) enjoying using spreadsheets when creating graphs, diagrams and tables; 7) liking three-dimensional puzzles; 8) music videos provide motivation and inspiration for learning and working; 9) can remember various events from photo documents; and is very good at reading maps and layouts of a place.

Smith, as quoted by Hafiziani (2017), stated that these spatial skills are very useful for communicating the position and relationships between objects, giving and receiving instructions, and imagining changes that occur in the position or size of shapes. NCTM also said that it is important for students to have spatial abilities, that

mathematics program instruction must pay attention to geometry and spatiality, so that all students can use visualization and spatial reasoning to solve problems both inside and outside mathematics (NCTM, 2000). So that students are able to develop their spatial skills and the ability to use geometric relationships to solve mathematical problems and everyday life.

Each person's spatial skills are different, including the spatial abilities of men and women. This is related to gender differences where gender greatly influences a person's spatial abilities. According to sociology and anthropology, gender is the behavior or division of roles between men and women, which is constructed or formed in a particular society and at a particular time (M. Thobroni, 2015). From the roles or behaviors that are included in their development in society, there is development that requires women who are gentle, emotional, beautiful, patient, and loving, as caregivers, housekeepers, and so on. While men must be strong, rational, authoritarian, powerful, breadwinners, and so on. Differences in development in society, the roles of men and women have an impact on their mental development and mindset in school education. Michael Guriaan, quoted by Meifiani (2015), explains the difference between the male and female brain lies in the size of the parts of the brain, how the parts are connected and how they work. There are 4 (four) fundamental differences in the brain between the two sexes, one of which is that in men, the brain tends to develop and have more complex spatial, such as mechanical design capabilities, measurement of abstraction direction determination, and manipulation of physical objects. Therefore, it is not surprising that men like to tinker with vehicle parts more than women.

Munawarah, M. (2023), said that gender differences in school education can occur in the acquisition of learning achievement. In principle, female and male students have the same rights and opportunities to actively participate in the learning process in the classroom. Women and men in each of these educational environments are equally open to accessing various learning facilities such as books in the classroom and so on. However, it is the teaching materials and attitudes of teachers that can subtly

affect their assessment of themselves and society. The learning material in question is that which differentiates the gender roles of men and women.

The development of a person's learning ability is also closely related to the level of intellectual and emotional intelligence. It is known that intelligence is determined by

the work of the brain. Anatomically, the development of the human brain, there are differences between the male and female brains that have been widely discussed over the past few generations and have developed rapidly. The differences in the structure of the male and female brains greatly affect their spatial abilities, as evidenced by research by M. Syahruddin Amin (2018), stating that the ability to imagine and create three-dimensional imaginary models of a movement, position, and others develops better in men than in women. This is manifested in the ability to design mechanically, measure the direction of abstraction, and manipulate physical objects. In line with this research, Herman (2019) also found that in solving geometry problems, one of which is related to mental rotation, men are generally more dominant in using the ability to imagine and then describe the results of their shadows, while women first describe the first rotation and then the second and the results of the rotation are obtained through logical reasoning. From the results of the study, it can be seen that this spatial ability is very closely related to brain development, and the brain development of men and women is clearly different so that there will likely be differences in the spatial abilities of men and women. Based on the results of initial observations conducted by researchers in the three-dimensional learning process. The three-dimensional is observed to be related to shapes with length, width and height with their competence in describing and determining distance in space. Researchers observed students' mathematical spatial abilities in solving geometry problems. The results of the observation showed that when the three-dimensional learning process, generally the work activities of male students were more active than female students, when the teacher showed a three-dimensional picture and it was known that a rib of a geometric shape, male students were able to mention other ribs, while female students needed time to think first, before mentioning the name of other ribs. Then when this three-dimensional material is also.

The teacher asked students to answer questions in front of the class, male and female students were able to solve the questions using the help of pictures and describe the solution to the problem, but differences were found, where male students could see the geometric shapes from different perspectives, while female students could mention formulas or concepts known to solve the problem.

Related to the spatial ability, both male and female students apparently each have different ways of solving problems related to three dimensions. Therefore, there needs

to be an in-depth study related to how and the process that male and female students go through in solving three-dimensional problems, so the author is interested in further research so that the author summarizes it with the title "Analysis of Mathematical Ability Reviewed from Gender Differences in Grade XII SMA/MA Students". This study aims to analyze in more depth the spatial mathematical ability of male students and the spatial mathematical ability of female students

2. Method

The approach used in this study is a qualitative approach. According to Moleong (2005), qualitative research is a study that produces data in the form of written or spoken words of people and observable behavior. According to Sugiyono (2016), qualitative research methods are research methods based on the philosophy of postpositivism, this is used for studies of natural object conditions (as opposed to experiments), where researchers are key instruments, data collection techniques, using triangulation, inductive data analysis, and qualitative research results emphasize meaning rather than generalization. The type of research used by researchers is descriptive research, which aims to directly describe students' mathematical spatial abilities when solving problems in three dimensions seen from gender differences in schools. The location of the research was conducted at MAN 4 Aceh Besar. The research subjects were 24 students of class XII MIA 3, to see students' spatial abilities, 24 students in the class will be given a spatial ability test in the form of three-dimensional questions.

Of the 24 students, 4 respondents were taken as subjects in this study. Then the subjects were interviewed. The data collection technique was carried out by providing a research test instrument in the form of spatial ability test questions on three-dimensional material totaling 2 questions and after that an interview was conducted on each of the research subjects. To formulate students' answers to the mathematical spatial ability test questions, they are categorized into spatial ability indicators, according to Zarkasyi (2017), namely: 1) Instructing and representing geometric models drawn on a flat plane in a spatial context. 2) Imagining the shape or position of a geometric object viewed from a certain perspective 3). Stating the position between elements of a geometric figure. 4) Investigating the actual size of the visual stimulus of a geometric object. Furthermore, to find out the category of students and each indicator in the three-dimensional material in mathematical spatial ability, namely by using the following categorization:

Table 1. Categories of Mathematical Spatial Ability

Value	Category
86 -100	Very Good
71- 85	Good
55 - 70	Sufficient
40 - 54	Less
0 – 49	Very Less

After the data on the spatial ability of the research subjects is collected and then data analysis is carried out in accordance with the qualitative data analysis method, with the stages of data reduction, data presentation, and drawing conclusions. Data reduction involves selecting relevant data from test results and interviews. After obtaining information about mathematical spatial ability, data presentation is carried out by combining the information obtained, and drawing conclusions is carried out as a formulation of research results with short, easy-to-understand sentences, and through repeated review of the truth of the conclusions. Data validity checking techniques consist of observer persistence, and triangulation. This study uses source triangulation to test the credibility of data obtained from mathematical spatial ability test instruments and interview results, archives or other relevant documents that support the achievement of research objectives

3. Result and Discussion

Based on the results of the written test of the acquisition of mathematical spatial abilities carried out by students using the instrument (Zarkasyi, 2017). The following is from Table 2 the results of the mathematical spatial ability test obtained below.

Table 2. Mathematical Spatial Ability Test Result Data.

Inisial Siswa	Total Nilai
MI	100
NF	90
MR	93
MZ	95

From Table 2, out of 24 students who took the mathematical spatial ability test, 4 students were taken as subjects for further examination. The four students with the category of mathematical spatial ability are very good to see the differences in the mathematical spatial ability of male and female students. Then the results of the students' work will be analyzed according to the indicators of students' mathematical spatial ability on the three-dimensional material as follows:

1. Mathematical Spatial Ability of Male Students

Based on the results of data analysis through test questions and interviews, the mathematical spatial ability of male subjects has very good spatial ability. It can be seen in the picture of the student's answer sheet below:

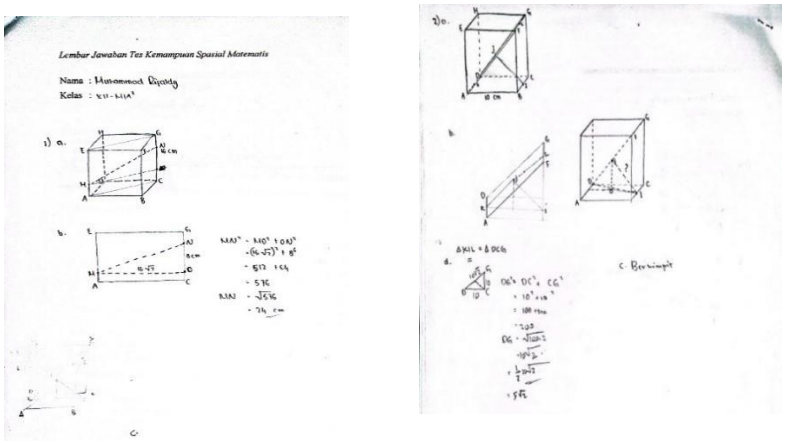


Figure 1. Answers of Male Student Subject MR

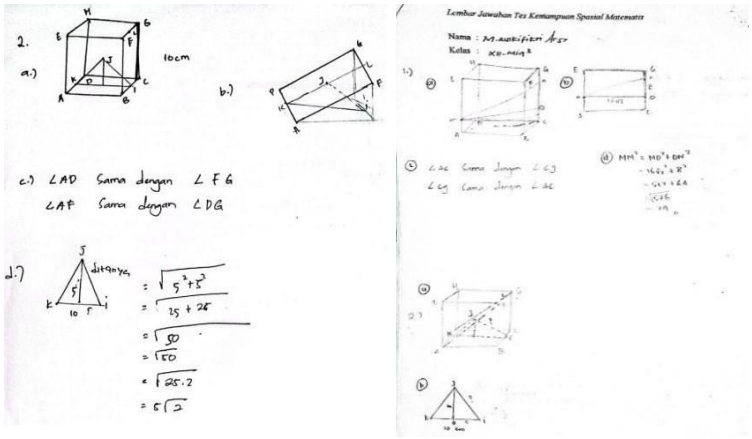


Figure 2. Answers of Male Student Subject MZ

On the indicator of instructing and representing geometric models drawn on a flat plane in the context of space, the results of the mathematical spatial ability test of the male

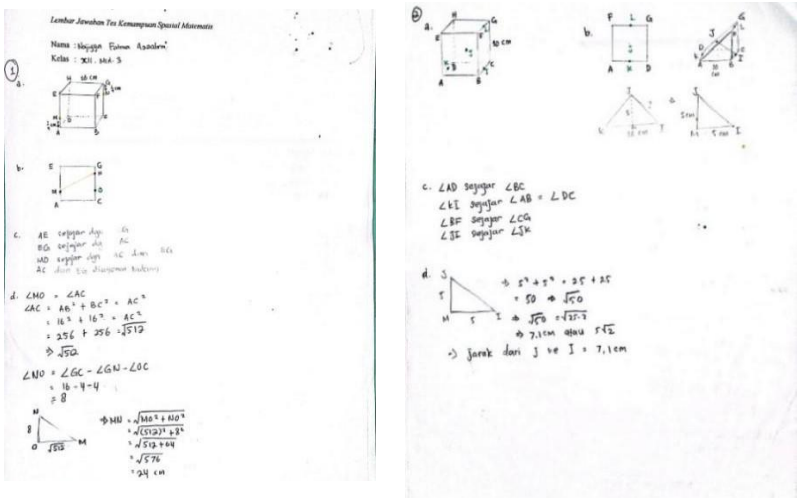
subject were able to describe a cube object and determine the location of the point properly and correctly according to the instructions given. The male subject was also very good at the indicator of imagining the shape or position of a geometric object viewed from a certain point of view, because the male subject was able to correctly and precisely describe the results of seeing objects from a certain point of view, the subject was able to describe another shape such as a flat shape in a spatial shape that was made. This is in line with the results of the study by Sefriana Dyah and Ratri Candra (2018), stating that male students were able to solve problems using the help of images and describe their solutions, were able to connect known data with existing concepts; were able to see problems from different points of view; and were able to find patterns in solving problems.

The indicator states the position between elements of a spatial shape. Observing from the male subjects, when given a written test in the form of spatial ability questions, it can be seen that the data from the mathematical spatial ability test results from men are not yet capable, because the male subjects do not provide good and correct answers, the subjects still seem confused to express what the position between the elements of a geometric figure is like. However, when the interview was conducted, the researcher gave a lure from a relevant example and after that the male subjects were seen to be able to mention the position between the elements of a geometric figure. This is because male subjects tend to think it is not important to write even though the male subjects actually know the answer. This is in line with the theory put forward by Eleanor Maccoby, quoted by Santrock (2007), that generally many men have better mathematical and spatial skills (skills needed by architects to design the angles and dimensions of buildings), while women have better verbal skills. When investigating the actual size of the visual stimulus of a geometric object, the male subjects seemed to have met the indicators because the subjects were able to use concepts in solving three-dimensional problems, by describing and determining the concept first, this would be easier when finding solutions to the questions given.

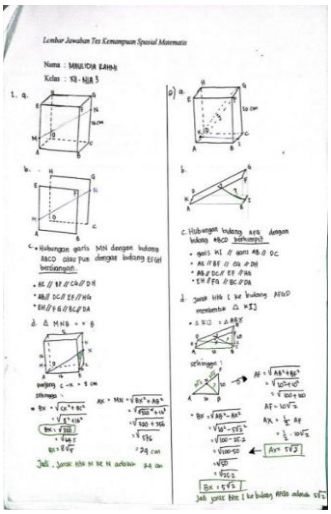
1. Mathematical Spatial Ability of Female Students

   Based on the results of data analysis through test questions and interviews, the mathematical spatial ability of female subjects has very good spatial ability. It can be seen in the picture of the student's answer sheet below:

Figure 3. Female Student Subject NF's Answers



Gambar 4. Jawaban Subjek Siswa Perempuan MI



Female subjects on the indicator instructing and representing geometric models drawn on a flat plane in the context of space, are able to describe objects according to instructions properly and correctly, because after being analyzed to describe this object is not difficult for female students as long as the instructions for the question are clear. Female subjects also fulfill the indicator of imagining the shape or position of a geometric object viewed from an angle.

Because the subject seems to be able to describe correctly, according to his own way of thinking. If observed from the indicators of instructing and representing geometric models, it turns out that male subjects think more practically, while female subjects think more elaborately. This is in line with the research of Kamila Ismi, et al. (2021), that in solving problems related to spatial orientation and spatial relations, male subjects use their

spatial abilities more than female subjects.

Female subjects appear very good at the indicator of stating the position between elements of a geometric figure, because the female subject gave the correct and precise answer by mentioning several positions between elements found in the object. This is in line with the opinion of Sherli Pitrah Dewi, et al. (2021) who said that the mathematical communication skills of female students are higher than the mathematical communication skills of male students. So it is easy for female subjects to express and write the position between the requested elements. If we look closely at the communication skills of women in language, they have more vocabulary than men. Looking at the growth and development between men and women at school age, many education experts agree that female puberty growth is faster than men. This is one of the reasons why women have more vocabulary in communicating than men. If we look further at the results of the mathematical spatial ability test, female subjects have better mathematical communication skills than male students. This is because female subjects are better able to express the relationship between parts of a geometric figure. When investigating the actual size of a visual stimulus of a geometric object, subjects appeared to be very capable of solving the problem using the chosen concept, and completing it in a step-by-step manner.

4. Conclusion

Based on the results of the research and discussion that the researcher has described above, both male and female students can meet all indicators of mathematical spatial ability. However, there are differences between male and female students in the indicator stating the position of the elements of a geometric figure. Male students tend to find it difficult to express the position between elements, male students consider this unimportant so that male students do not write the position between elements, but when asked through interviews male students are able to answer it, while female students are able to write and express the position between the elements. Furthermore, in the indicator identifying the concept contained in the object, and determining the actual size of the geometric object, male students solve problems practically with the concept used, while female students solve them in stages and completely. It can be concluded that the mathematical spatial ability of male students is faster and more precise when thinking spatially while female students are full of caution and more careful than male students who will need more time.

This research is expected to provide benefits for the world of education and as a

consideration for improving mathematical spatial ability in mathematics learning. Suggestions for other researchers in the future are to take subjects based on categories of at least two subjects per category so that there is a more accurate comparison of results to be used as conclusions from the research.

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