GENDER DIFFERENCE IN MATHEMATICAL SPATIAL ABILITY AND FACTORS THAT MAY AFFECT IT

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Abstract:
This study aims to quantitatively investigate the spatial ability differences between male and female students to provide empirical evidence. In this study, 36 high school students took the sample. Spatial ability tests are used to gather data about student spatial abilities. The data is then analyzed using a T-test to test the hypothesis. The results of the study showed that there were significant differences between the spatial abilities of male and female students, and in general or as per gender, the student's space capacity was still low. Factors that may influence significant gender differences are biological and social-cultural, while the student's spatial abilities are still low because the students are not accustomed to getting training on issues related to space abilities. The use of learning media for student spatial abilities is not optimal.

Keywords: Spatial Abilities, Gender, Differences, Male Students Dominate

PERBEDAAN GENDER DALAM KEMAMPUAN SPASIAL MATEMATIS DAN FAKTOR-FAKTOR YANG MUNGKIN MEMPENGARUHINYA

Abstrak:
Penelitian ini bertujuan untuk menyelidiki secara kuantitatif perbedaan kemampuan spasial antara siswa laki-laki dan perempuan untuk memberikan bukti empiris. Dalam penelitian ini, 36 siswa Sekolah Menengah Atas (SMA) menjadi sampel. Tes kemampuan spasial digunakan untuk mengumpulkan data tentang kemampuan spasial siswa. Data tersebut kemudian dianalisis menggunakan uji T untuk menguji hipotesis. Hasil penelitian menunjukkan bahwa terdapat perbedaan yang signifikan antara kemampuan spasial siswa laki-laki dan perempuan, dan secara umum ataupun dilihat dari jenis kelamin kemampuan spasial siswa masih rendah. Faktor yang mungkin mempengaruhi adanya perbedaan yang signifikan berdasarkan jenis kelamin adalah faktor biologis dan faktor sosial budaya, sedangkan masih rendahnya kemampuan spasial siswa disebabkan oleh siswa yang tidak terbiasa mendapat latihan soal terkait dengan kemampuan spasial. Penggunaan media pembelajaran untuk kemampuan spasial siswa belum optimal.

Keywords: Kemampuan Spasial, Gender, Perbedaan, Siswa Laki-Laki Dominan

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INTRODUCTION

NCTM stated that geometry as one of the five standards contained in the mathematical standard is compulsory for master students. Geometry presents abstractions derived from visual and spatial experiences, such as fields, patterns, measurements, or mapping. In addition to developing students' cognitive abilities, geometry also helps in shaping memory, i.e. changing concrete objects into abstract ones. Furthermore, geometry becomes a tool for understanding the universe because it is written in mathematical language as triangles, circles, and other geometric objects. In short, it is important for students to have spatial abilities because many concepts in geometry require students to visually see objects identify properties, and imagine the movement and internal orientation of objects. Visual awareness will enable students to perform geometric problem-solving using image forms in two or three dimensions (Harahap, Surya, & Syahputra, 2018; Akayuure, Asiedu-Addo, & Alebna, 2016).

Spatial ability is one of the nine intelligences in the theory of multiple intelligences (Gardner & Hatch, 1989) defined as the ability to revive, maintain, regain, and change visual shadows. Another understanding of spatial abilities (Harahap, 2020) is The ability to permeate representation, transformation, and recall of symbolic information. Students need spatial skills to solve problems in their lives such as reading maps, map-based information, and computers, when carrying out packaging ought to think of boxes that will be used enough or not carrying items to be packed. In addition to mathematics, many fields of study require spatial skills such as natural sciences, engineering, meteorology, economic prediction, and architecture because they involve visual space thinking.

The elements of spatial ability consist of five parts, namely: 1) Spatial perception; perception is the ability to observe a spatial structure or parts of space placed horizontally or vertically. 2) Spatial visualization; Spatial visualization is described as the ability to manipulate visual images or imagine images of a spatial structure in which parts change or move. 3) Mental

rotation; Mind rotation includes the ability to rotate a spatial structure quickly and precisely. 4) Spatial relations; The ability to understand the spatial form of an object or part of an object and the relationship between one part and another. 5) Spatial orientation; Refers to the cognitive ability of seeking one's guidance physically or mentally in space, or orienting in special spatial situations (Isnaini, 2020; Alimuddin & Trisnowali, 2019).

Piaget and Inhelder (in Hibatullah, Susanto, & Monalisa, 2020) speaking of spatial ability as an abstract concept, it encompasses space relationships; the ability to observe relationships between objects in space; the framework of reference; the sign used as a benchmark to determine the position of objects within space. Projective relationships; the ability to see objects from different angles. Conservation of distance; the ability to estimate the distance between two points; spatial representation; the capacity to represent space relationships by cognitive manipulation. Mental rotation; imagining the rotation of objects in space. We all need to know that the spatial abilities of each student are not the same. The differences in spatial abilities that are often discussed are based on gender.

Understanding gender in the Women's Studies Encylopedia (in Saputra, 2020) is the difference that appears between men and women in terms of values and behavior. Gender as a concept is the result of human thought or human engineering, formed by society so that it is dynamic and can differ due to differences in customs, culture, religion, and value systems of certain nations, communities, and ethnic groups. Apart from that, gender can change due to the course of history, political, economic, social, and cultural changes, or due to development progress. Thus, gender is not universal and does not apply in general, but is situational in society. There are physical differences between the brains of men and women, causing differences in behavior, emotional differences, thinking patterns intelligence, development, and cognitive processing (Wiwied & Hadiyanto, 2023).

Differences in the brain structure of men and women can also have implications for their spatial abilities, as research has shown Amin (in Maghfiroh, 2023) states that the ability to imagine and build three-dimensional imaginary models of movements, positions and so on is better developed in men than women. This manifests in the ability to design mechanically, determine the direction of abstractions, and manipulate physical objects so that many men enjoy tinkering with or making modifications to various objects.

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Many studies on spatial abilities based on gender have been carried out in Indonesia, one of which is research entitled "Mathematical Abilities of Men and Women" conducted by Yeni Tri Asmaningtias (Nafi'ah, 2014). Asmaningtias stated that men's spatial abilities are better than women's. In this study, an instrument was given which included questions to test spatial abilities. The data obtained shows that in solving spatial questions the male group and the female group differ in their answers. The male group relied on spatial strategies when completing the mental rotation task, while the female group tended to use verbal strategies. In line with the discoveries made by Ismi (2021) in research conducted qualitatively. Men's spatial abilities are more dominant than women's when solving problems related to spatial orientation and spatial relations.

Contrary to the results of the research just described, Ganley and Vasilyeva's findings (Yumniyati, 2016) stated that there was no difference in spatial abilities between female and male subjects. In line with the findings of Imamuddin and Isnaniah (2018) who revealed that there was no difference in the spatial abilities of male and female subjects in spatial visualization. The absence of differences in ability between 39 male subjects and 88 female subjects of class X SMAN 1 Salatiga was stated in the results of Handayani, Sutriyono, and Prihatnani (2020) research, The average spatial abilities of men and women respectively are 15.87 and 14.33.

The majority of these studies use qualitative research methods to examine gender-based disparities in spatial ability. Therefore, the findings of earlier studies are limited to the subjects that were examined and cannot be generalized. To bridge the gap left by earlier qualitative research, this study attempts to examine and analyze gender disparities in spatial ability from a new angle—namely, a quantitative one. Quantitative research can help to see whether the differences are significant or not. Previous research was conducted qualitatively so there may be differences between female and male students in spatial abilities, but it is not yet certain whether the differences are significant. This research contributes to complementing previous qualitative research on gender in spatial abilities. Furthermore, this research provides empirical evidence of the differences reported by previous research. Possibly contrary to previous findings or even in agreement. This can help teachers to identify whether gender contributes to differences in students' spatial abilities. This research is accompanied by a discussion of factors that might influence the findings later, whether there are significant differences or not. With the

hope, that teachers can create various more appropriate strategies to facilitate students according to their gender equally to improve spatial abilities and create different learning processes.

METHODS

This research is quantitative descriptive research. Research is carried out by collecting results that occur naturally in the field without manipulating any variables. The research subjects were 36 class X high school students in Ambon, Indonesia, consisting of 24 female students and 12 male students. All subjects were given a spatial ability test on geometry material as a data collection instrument. The test instrument is the result of an adaptation of an instrument developed in research conducted by Ismi (2021); Hibatullah, Susanto, and Monalisa (2020). The test questions are in the form of a description of eight questions.

Table 1. Types of Spatial Abilities

Types of Spatial Ability	Question Indicator	Question Number
Spatial Orientation	Students can determine the appearance of objects from different perspectives.	1
Spatial Relation	Students can determine the relationship of an object with other objects.	2
Spatial Perception	Students can differentiate between lines, horizontal planes, and vertical planes in spatial figures.	3
	Students can identify objects vertically and horizontally even though the position of the object is manipulated.	4
Spatial Visualization	Students can solve problems related to stacked objects of unit cube shapes whose position or shape has been manipulated.	5a 5b
	Students can visualize stacks of unit cubes from more than one point of view.	6
Mental Rotation	Students can rotate a plane shape or space shape and imagine the rotation of the plane shape and space shape correctly.	7 8

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Before the instrument was used, the instrument was first validated by 2 mathematics education lecturers and 1 mathematics teacher, then revised according to suggestions from the validator. Next, a readability test was carried out on 5 classes The spatial ability test was given to research subjects with a processing time of 90 minutes. The results of the spatial ability test were then analyzed using comparisons to determine differences in spatial ability between male and female students. Before the comparison test, a normality and homogeneity test is first carried out to determine the comparison test that will be used, namely parametric analysis or t-test non-parametric or Mann-Whitney U test.

Table 2 shows a guide to interpreting students' spatial ability scores to clarify the general picture of the level of spatial ability based on the student's gender perspective. Student abilities are then categorized based on the Benchmark Assessment adapted from Ratumanan & Laurens (2015).

Table 2. Benchmark Assessment

Interval	Category
$x \geq 75$	High
$60 \leq x < 75$	Medium
$x < 60$	Low

RESULTS AND DISCUSSION
1. Student Spatial Ability Profile

This research aims to find out whether there are differences in the spatial abilities of class X high school students in Ambon based on gender differences, namely male and female students. The number of research subjects was 36 students. To determine spatial abilities, students are given a spatial ability test. In this test, 5 elements of spatial ability are measured, namely: spatial perception, spatial visualization, mental rotation, spatial relations, and spatial orientation. The test material is geometry which consists of 8 questions. The categorization of student scores based on table 2 consists of high, medium, and low categories. Figure 1 shows the frequency of students' spatial abilities and Figure 2 shows the percentage of students' spatial abilities.
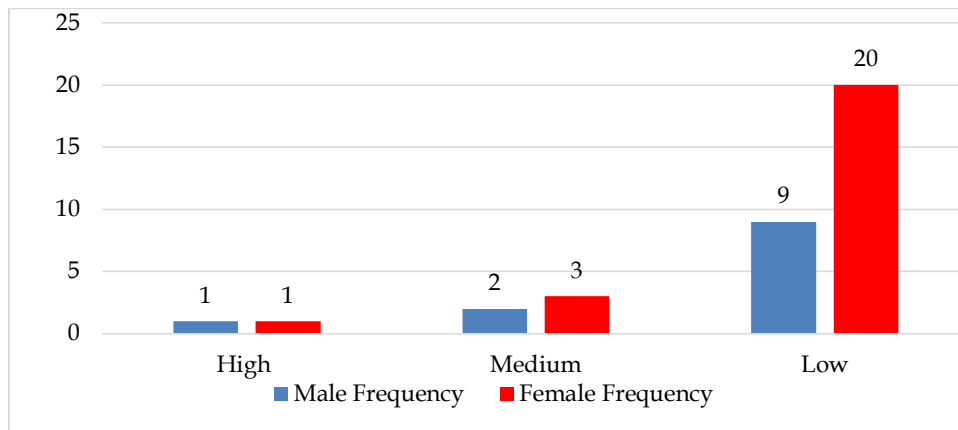
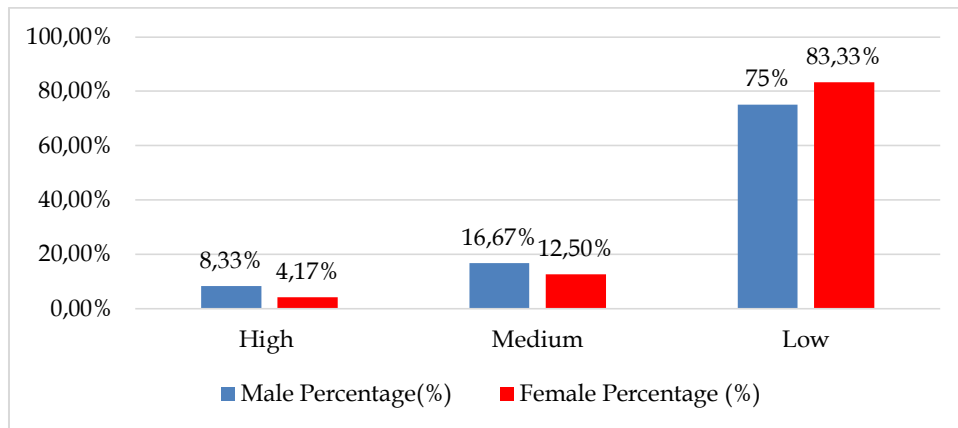Figure 1. Frequency of Students' Spatial Ability Level

Figure 2. Percentage of Students' Spatial Ability Level

Based on figure 1, shows that for high spatial abilities, there is only one male and one female student each. At medium ability, there are 2 male students and 3 female students. The most numerous were students who had low spatial abilities, namely 9 men and 20 women. In Figure 2, we can see that the percentage of male students is greater than the group of female students in high and medium spatial abilities of 8.33% and 16.67%. Meanwhile, with low spatial ability, the percentage of female students is greater, reaching 83.33%. Figure 3 shows the average spatial ability of students based on gender (male and female) and in general.

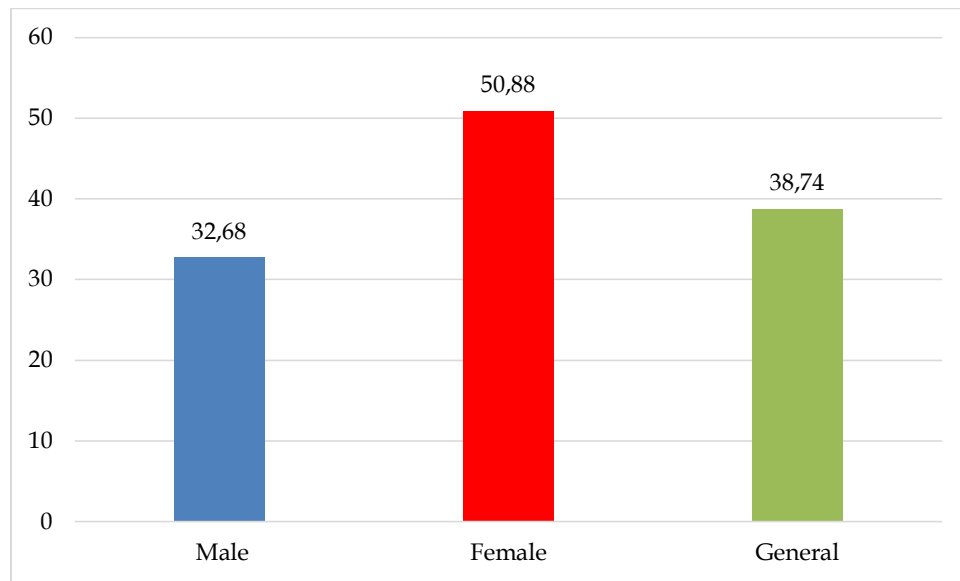*R. H. Yanti Silitonga[1), T. G. Ratumanan[2), Ester Telambanua[3)*

Figure 3. Average of Students' Spatial Ability

Based on figure 3, shows that there is a difference in the average spatial ability of male and female students of 18.2. However, it is still necessary to test assumptions to ascertain whether the differences in the average spatial abilities of male and female students are significantly different or not significant by conducting statistical tests.

Table 3. Normality Test

Gender	p-value	Decision
Male	0.750	Normal
Female	0.123	Normal

Table 4. Homogeneity Test

	P-value	Decision
Spatial Ability	0.601	Homogeneous

Table 5. T Test

	P-value	Decision
Spatial Ability Difference of Male and Female Students	0.017	Rejected the null hypotenuse

Inferential statistics in this study use two hypothetical groups because the research data is independent and only uses groups of male and female students. Before carrying out the analysis, it is first necessary to carry out a normality test using Shapiro-Wilk. The significance value obtained by the male student group was 0.750 and female students 0.123, meaning the data was normally distributed. Next, check homogeneity using Levene's test. Based on Table 4, shows a sig value of 0.601, meaning that the spatial ability data for the two groups is homogeneous. Because the data from both groups are normal and homogeneous, the T-test was used to test the research hypothesis. Based on Table 5, the p-value is less than five percent so the null hypothesis is rejected. It can be interpreted that there are significant differences in spatial abilities between male and female students.

2. Female and Male in Spatial Ability

This research aims to obtain empirical evidence of students' spatial abilities from a gender perspective. The results of the analysis process showed that there were significant differences between the spatial abilities of male and female student groups. The findings of this study are contrary to the results of research which states that the spatial abilities of female subjects and male subjects have no difference (Yumniyati, 2016; Imamuddin & Isnaniah, 2018; Halizah, 2023).

However, the results of this study are in accordance with research from Nafi'ah (2014) and Ismi (2021), namely that male students' spatial abilities are more dominant. Students' spatial abilities are still low, in line with the results of an investigation conducted by Halizah (2023), namely that three-quarters of all students did not meet the minimum completeness criteria (KKM) in the side spatial structure material.

3. Factors that Might Influence It

To find out the factors that might influence students' low spatial abilities, and the existence of differences in abilities based on gender, researchers conducted interviews with mathematics teachers and identified students' spatial processes through answer sheets. It appears that men's spatial abilities are superior to women's, with the average spatial ability of men being 50.88 and the average spatial ability of women being 32.68. In this case, it can be seen that the difference in spatial ability between men and women is 18.20.

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This is by Michael Guriaan's book Michael Guriaan (Yumniyati, 2016) where in men, the brain tends to develop and have complex spatial abilities, such as the ability to design mechanically, measure abstract direction, and manipulate physical objects. Furthermore, the results of the analysis of the differences and similarities between men and women revealed that women's brains are smaller than men's brains, but women's brains have more folds compared to men's brains. These folds are convolutions, where the surface is covered by a thin membrane located inside the skull and this layer is more common in women. Meanwhile, the parietal lobe area, which functions to hone visual-spatial skills, tends to be larger in men than in women.

Apart from biological factors, social and cultural factors cause men's spatial abilities to be more dominant. In terms of the socio-cultural environment, researchers concluded that men have more opportunities to develop their spatial abilities than women. Games from childhood, daily activities, sports, parents' expectations, and the surrounding environment, even men's work, have a big influence on the development of their spatial abilities. When they were young, most boys played with vehicles and blocks which involved spatial manipulation while girls played with toy animals and dolls which helped develop their social skills. Men's sports such as football and basketball also require greater spatial abilities than sports usually played by women such as swimming and running. In terms of work, several jobs that require high spatial abilities are more often chosen by men, such as pilots, engineers, and surgeons (Asis, Arsyad, & Alimuddin, 2015).

Based on the results of interviews with students, there was material on flat-sided spatial shapes. Students found it a little difficult to imagine each form of spatial shape, so media was needed. This is in line with several studies that state that the use of media allows students to understand flat-sided geometric material better and can improve spatial abilities (Khoriyani & Suhendra 2022; Halizah, 2023; Nasution 2017). In geometry lessons, teachers rarely provide practice on geometric shapes related to spatial abilities. To minimize spatial ability problems, teachers are expected to provide lots of exercises related to spatial construction to overcome students' weak spatial abilities caused by gender differences.

This is in line with what was stated by Alimuddin and Trisnowali (2019) and Saputro (2020) who stated that gender differences in spatial abilities can be eliminated with practice. Several ways to improve spatial abilities based

on Several ways to improve spatial abilities based on Alghadari's (2020) literature study are using spatial language in daily interactions, teaching sketches and drawings, using suitable games, using tangrams, using video games, and using origami and folded paper. Literature study uses spatial language in daily interactions, teaching sketches and drawings, using suitable games, using tangrams, using video games, and using origami and folded paper.

CONCLUSION

The findings show that there are significant differences in the spatial abilities of male and female students. Apart from that, both in general and in terms of gender, students' spatial abilities are in the low category. This research also suggests the importance of implementing mastery of spatial abilities in classroom learning to support students to have good spatial abilities. The lack of application of spatial abilities in the classroom causes low student abilities. In addition, although this research reveals factors that have the potential to influence students' spatial abilities, further research still needs to be carried out to see what variables significantly influence students' spatial abilities.

This research has only been carried out in one school, therefore, it is hoped that research can be carried out in many schools so that more accurate and general findings can be obtained and more factors can be identified related to spatial ability. Different schools may have other factors that can influence students' spatial skills. It is best when explaining a lesson that teachers use media (props) so that students can understand the meaning of the lesson with the same interpretation. Teachers should continue to provide explanations, especially in the geometry chapter, by paying attention to the characteristic abilities of each student. To achieve good quality education, schools should first understand the different skills of students. With this, the best learning results will be obtained for students.

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