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Gender Differences in Students' Spatial Abilities: A Systematic Literature Review Analysis in Educational Contexts

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Abstract: In the midst of increasingly sophisticated technological developments today, spatial ability is one of the important abilities that must be mastered by students. The research is included in the SLR (Systematic Literature Review) research method. Through a literature review of 30 studies, the research sought to identify common patterns, influencing factors, as well as the implications of such gender differences. The analysis showed a tendency for males and females to differ in certain aspects of spatial ability, particularly in tasks involving mental rotation and spatial visualization, with males outperforming females. However, these findings are not always consistent across studies, and various factors such as biological factors such as age, cognitive factors such as learning style, social environmental factors, and individual emotional factors also play an important role that can affect spatial ability. This research also identified a diversity of research methods used in previous studies, ranging from quantitative to qualitative approaches. This demonstrates the complexity of researching this phenomenon. In addition, most of the studies focused on upper secondary students, so further research is needed to understand gender differences in spatial ability at lower levels of education. The findings of this study have significant implications for educational practice. Teachers need to create learning environments that are inclusive and stimulate the development of spatial abilities of all students, regardless of their gender. The use of various learning strategies involving object manipulation, visualization and problem solving can help improve students' spatial abilities. Further research is needed to develop effective interventions to improve spatial ability in all students, study the factors of spatial ability development, conduct cross-cultural studies to study the influence of cultural factors on gender differences in spatial ability. In addition, cross-cultural research is also important to understand how social and cultural factors affect the development of spatial ability.

Keywords: spatial ability, spatial ability factors, gender differences.

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INTRODUCTION

Spatial ability is a cognitive foundation underlying many aspects of human life (Nejati et al., 2024; Yuan et al., 2019). They enable individuals to understand, analyze, and interact with the physical world effectively. In an increasingly complex digital age, spatial abilities are becoming increasingly relevant to everyday life (Ebert & Jansen, 2024). The ability to visualize data, manipulate objects in three-dimensional space, and understand spatial relationships between various elements are becoming highly sought-after skills in a variety of fields, from science and technology to art and design. Spatial

abilities must be mastered by students in the midst of today's increasingly sophisticated technological developments. Spatial ability is an ability related to space and location. Spatial ability allows students to understand and visualize between objects, shapes, and spaces or spatial relationships (Aliman et al., 2013). Students with high visual spatial intelligence tend to think visually (Maulid, 2023). Therefore, although technology is available that makes it easier for students to find the location of the destination, if it is not accompanied by spatial abilities, then the technology is not fully helpful.

In the context of education, spatial ability plays an important role in various subjects, especially math and science (Yang et al., 2024). The ability to visualize geometric shapes, understand the concepts of distance and direction, and perform mental rotation are indispensable skills for solving problems in this field. To improve spatial abilities in students can be done through the provision of spatial-based learning, one of which is geography learning (Isnaini et al., 2023). Because in geography learning, problems are always related to space or spatial (Aliman et al., 2023). The problem that is felt at this time is due to the breadth of material and the number of elements studied in social studies material, so social studies is known as memorized material with limited delivery time (Vidiawati & Gunansyah, 2023; Amelia et al., 2022; Wulandari, 2018). In addition, social studies learning usually discusses topics that are not only related to the fields around students, but also other fields. (Vidiawati & Gunansyah, 2023).

In addition to social studies learning, spatial skills are also needed in math learning. Imagining, selecting, or reversing two- or three-dimensional objects is part of geometric thinking that requires visualization or spatial skills. (Ainurrahmah et al., 2023). Therefore, spatial ability is needed in geometry material, because many students still have difficulty in answering simple problems, errors in understanding geometry concepts, difficulties in analyzing mathematical problems, errors in spatial visualization related to the mathematical perspective used, difficulties in understanding concepts, difficulties in using principles, and difficulties in solving problems (Adelia & Wandini, 2023).

Another urgency that shows the spatial abilities of students in terms of gender can be seen from research by (Maghfiroh, 2023) which shows the fact that male student subjects are more dominant in the aspect of space visualization when compared to female student subjects as seen from their ability to solve contextual problems in the given problem with the idea of determining the name of the building from the story problem.

Although the importance of spatial ability has been recognized, many studies show that this ability is still underdeveloped in many students, especially at the primary school level. Some factors that may influence the development of spatial ability include genetics, learning experiences and gender (Humphreys et al., 2020). Previous research has shown gender differences in spatial ability, with males tending to excel in some aspects of spatial ability more than females (Bartlett & Camba, 2023). However, these findings are still controversial and need further research.

One of the main challenges in developing spatial ability in students is the lack of attention to spatial aspects in the education curriculum. Many curricula tend to emphasize verbal and quantitative aspects, so spatial abilities are often neglected. In addition, learning methods that are still conventional and less varied can also hinder the development of students' spatial abilities. The importance of developing spatial abilities early on has encouraged researchers and educators to look for effective ways to improve these abilities. Various approaches have been developed, including the use of technology, games and manipulative-based activities. However, more

research is needed to identify the most effective approaches in different contexts.

Therefore, this study aims to examine the spatial abilities of school students with a focus on gender differences. This study will answer the research questions regarding the extent of spatial ability of school students, and whether there is a significant difference between male and female students in terms of spatial ability. Thus, this study is expected to contribute to a better understanding of the development of spatial abilities in early childhood as well as provide recommendations for curriculum development and learning that are more effective in improving students' spatial abilities.

The method used in this study is a systematic literature review (SLR) of relevant literature to identify research trends, knowledge gaps, and factors that influence gender differences in spatial ability. Through this SLR, it is expected to gain a deeper understanding of the factors that contribute to gender differences in spatial ability, as well as the implications of the findings for educational practice. A systematic literature review was chosen as the research method because it allows for a comprehensive analysis of a large number of previously conducted studies. Using this method, the researcher can identify relevant studies, evaluate the quality of these studies, and synthesize the findings in a systematic manner. Some of the research questions to be answered in this SLR include: (1) What are the most frequently studied factors in relation to gender differences in spatial ability?; (2) What research methods are most commonly used in these studies?; (3) What are the main conclusions that can be drawn from previous research on gender differences in spatial ability?.

By answering these research questions, it is hoped that a clearer picture of the current state of research and future research directions can be obtained. The results of this SLR are expected to contribute to the development of theory and practice in the field of education, especially in efforts to improve spatial abilities in students.

METHOD

Research Design

This study used the Systematic Literature Review (SLR) approach to analyze and synthesize findings from previous studies on students' spatial abilities, particularly in relation to gender differences. SLR was chosen as the research method because it allows for a systematic and comprehensive review of a large amount of relevant literature (Ikhsan et al., 2024; Satria & Khoirunnisa, 2024; Selviyani et al., 2024). While the research stages using the SLR method are referring to the 5 stages according to (Suhaedin et al., 2024) as follows:

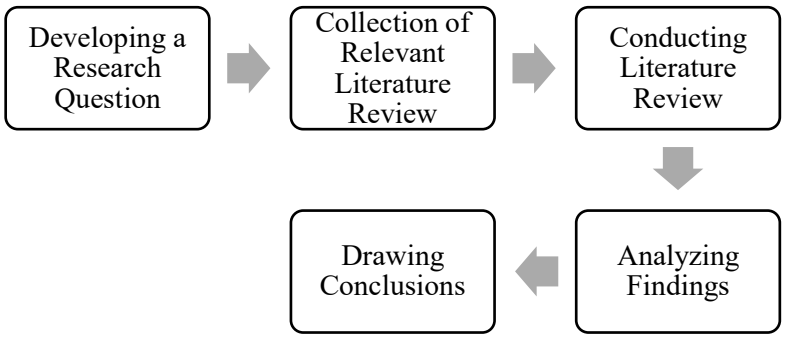

Figure 1. Stages of literature review

The literature review begins with developing specific and focused research questions, narrowing down the research topic and identifying problems or knowledge gaps. Then, relevant literature was collected through academic databases using specific keywords. The collected literature was then read and analyzed to identify concepts, theories and research methods.

After that, the findings from the collected literature were analyzed to identify patterns, similarities and differences. The data was then organized and analyzed to identify research results. The results of this analysis were then used to answer the research questions and develop recommendations for further research. Finally, clear and structured conclusions are drawn based on the findings and analysis.

Search Strategy

The literature search strategy was conducted using a combination of relevant keywords, such as "spatial ability," "gender differences," "elementary school students," "middle school students," "high school students," "geography," "mathematics," "geometry," "visualization," "mental rotation." Databases used in the initial search included Google Scholar, Scopus, Web of Science, ERIC, and ProQuest.

The search process was conducted in stages according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart. The stages in the search process include:

1. Identification: An initial search is performed on a predefined database using a predefined combination of keywords.
2. Screening: Articles obtained from the identification stage were subjected to initial screening based on the title and abstract to select articles relevant to the research topic.
3. Selection: Articles that passed the screening stage were fully selected based on the content of the article to ensure the relevance and quality of the research.
4. Data collection: Relevant data from the selected articles were collected and entered into the data extraction table.
5. Data analysis: The data collected was analyzed through thematic and qualitative data coding to identify themes, patterns and key conclusions.

Inclusion and Exclusion Criteria

1. Inclusion criteria in this study included: a) Type of publication:Scientific journal articles that have been published in reputable journals. b) Language: Articles in English and Indonesian. c) Population: Research involving elementary, middle, or high school students. d) Topic: Research that addresses students' spatial abilities, particularly in relation to gender differences. e) Research method: Research using quantitative or qualitative methods.
2. Exclusion criteria in this study include: a) Type of publication: Books, research reports that are not published in scientific journals. b) Language: Articles in languages other than English and Indonesian. c) Population: Research that does not involve elementary, middle, or high school students. d) Topic: Studies that did not address students' spatial abilities or did not address gender differences. e) Research methods: Research that does not use quantitative or qualitative methods.

Data analysis

Data obtained from various studies were systematically collected and analyzed using the Systematic Literature Review (SLR) approach. The data analysis process was carried out in several stages, namely:

1. Data Coding: Data from each study were coded into relevant categories, such as: a) Participant characteristics (gender, educational background. b) Type of spatial task used. c) Measurement instruments used. d) Study results (presence or absence of gender differences, significance of differences)

2. Thematic Analysis: The data that has been coded is then analyzed thematically. Thematic analysis is done by grouping data based on similarities and differences.
3. Qualitative Analysis: Qualitative analysis was also conducted to explore a deeper understanding of the factors that influence gender differences in spatial ability.

■ RESULT AND DISCUSSION

The Relationship Of Spatial Ability To Gender Differences

Spatial is everything related to the concept of space. Spatial ability means the ability of an individual to imagine objects or space in three dimensions and understand their relationship with each other (Aliman et al., 2023). Spatial is an ability that includes: (1) understanding of interrelationships, especially regarding seeing the relationship between the position of objects in space; (2) frame of reference, related to the ability to read symbols, for example symbols to determine the position of objects in space; (3) relational planning, which is about the various ways we see things; (4) ability to maintain distance, namely comparing distances; and (5) spatial representation, namely seeing the relationship between the position of objects in space (Azustiani, 2017; Maulid, 2023; Wijaksana & Kusumah, 2023). Through this spatial ability, it is possible for someone to abstract an image object. This is because the ability to imagine thoughts and the ability to create something abstract can be produced from spatial intelligence (Linda et al., 2023). Based on some of these explanations, it can be concluded that spatial ability is the ability to visualize image objects into the concept of space and the relationships that occur therein. Basic cognitive abilities, such as recognition, encoding, storage, representation and decoding, are part of spatial ability (Yang et al., 2024).

Spatial ability according to Maier is divided into five aspects including: mental rotation, perception, visualization, orientation and spatial relationships (Imamuddin & Isnaniah, 2018; Teapon & Kusumah, 2023; Usman et al., 2020; Wijaksana & Kusumah, 2023; Yuliardi & Casnan, 2017). Furthermore (Teapon & Kusumah, 2023) explained the five elements of spatial ability as follows: (1) Spatial perception, includes a person's ability to understand and assess spatial relationships which include the ability to manipulate objects in space, and visualize data in spatial form. (2) Spatial visualization, including the ability to draw or match pictures, being able to answer multiple choice questions or written answers related to the visual representation of the object or situation requested. (3) Mental rotation, consists of a series of questions or tasks that require one to visualize and rotate objects in their mind. (4) Spatial relationships, relates to a person's ability to understand and recognize spatial relationships between objects or elements that exist in space. (5) Spatial orientation, includes a personal understanding of the way objects or elements are connected in a three-dimensional environment, including their direction, position, and spatial relationships. To understand further (Franselaa et al., 2021; Narpila, 2019) designed indicators based on the five spatial aspects summarized in the following table:

The spatial skills of students in elementary, junior high, and high school are different. Male students are usually better at math because of their focus on abstract, intellectual, and objective things, while females focus on more concrete, concrete, emotional, and personal things (Dilla et al., 2018; Ikhwani, 2021). Men have good math, spatial, and logical skills, while women have good verbal, linguistic, and interpersonal skills (Reilly et al., 2016). There are many advantages obtained from spatial learning, including students being able to identify, describe, explain, and communicate information about objects in related spatial relationships through the use of representation tools such as maps, diagrams,

Table 1. Spatial aspect indicator

Spatial Aspects	Description	Indicator
Spatial perception	Understanding that the shape and size of the subject does not change even if the stimulus is different from what we perceive based on that point of view.	Can show the actual condition, size or shape of a three-dimensional display.
Visualisation	The ability to imagine changes in the shape or arrangement of parts of an object.	Can show the actual condition (shape) of a change in the arrangement or parts of a particular object.
Mental Rotation	An ability to think quickly and precisely about the rotation of two-dimensional or three-dimensional objects.	Able to show the shape or position of a building through rotation.
Spatial Relation	The ability to understand the shape of an object or its components and their relationship to each other.	Can show the relationship between elements in the third dimension, i.e. the relationship between points, planes and lines.
Spatial Orientation	The ability to identify the shape or arrangement of an object in a particular situation and perspective.	Able to describe the shape of an object from various perspectives and situations.

graphs, sketches, flow charts, models, and so on to be able to solve problems, find answers, and provide solutions related to spatial or spatial problems. (Metoyer & Bednarz, 2017). In addition, students who have spatial abilities in themselves allow them to have the ability to: (a) Visualize objects. (b) Make pictures well. (c) Identify and remember directions. (d) Read and interpret maps, diagrams, or illustrations. (e) Solve spatial problems. (f) Navigating in the physical environment and understanding spatial relationships between objects (Harahap et al., 2023).

Gender is the separation of duties, signs, personality traits, and behaviors that are formed and developed in society (Aniqurrohmah, 2023). Gender is an important concept that is more than just a term but changes the way society views how men and women do things and roles, and opposes the division of roles based on biology (Anwar, 2015). Therefore, gender is also defined as differences seen from a social perspective between men and women, as well as elements related to the behaviors, roles, and rights given to men and women (Ns, 2017).

From the discussion above, there is a similar concept that gender is not only limited to distinguishing men and women based on their sex but also includes the roles and responsibilities that exist in it. Talking about gender, of course, cannot be separated from discussing gender equality. To realize gender equality in society is to provide gender-oriented family education (Noviani et al., 2022). as research conducted by (Rahmayanty et al., 2023) shows that implementing a democratic system in the family can be the first step in the struggle for gender equality. Families have the responsibility of providing an understanding of gender to their children. Because children who understand their gender identity well will believe themselves to be male or female, therefore gender identity is very important for children so that they can act and behave according to their identity (Sary et al., 2023). Not only from the family environment, schools also play a role in providing gender education to students.

Schools are responsible for ensuring that gender education does not stop at the knowledge level but is also applied in real life (Khairunnisak et al., 2023).

In education, gender differences in spatial ability have been a topic of interest. Differences in certain cognitive abilities, such as spatial ability, between males and females are possible, although there are no significant differences in general intelligence (Reilly et al., 2016). Across studies examining spatial ability in terms of gender differences, males outperform females in both large-scale and small-scale abilities, although gender differences are not uniform across all types of spatial tasks (Yuan et al., 2019). Moreover, factors such as the type of spatial task, individual interest and engagement, and regional differences can also influence gender advantage in spatial ability (Tsigeman et al., 2023). For example, individuals who live in different places may have different levels of spatial skills, moreover, age also affects a person spatial ability (Yuan et al., 2019).

Gender bias can be defined as social and cultural characteristics or characteristics that favor men and disadvantage women. However, ultimately, the concept can also be used for situations where men are at a disadvantage, such as when men are in an adverse situation. From the phenomena that occur above, research is needed to prove whether or not there is an influence of gender differences on students' spatial abilities. Here are some studies that examine the effect of gender differences on spatial abilities presented in table 2:

Table 2. Relevant research studies

No	Researcher	Method	Research Subjects and Results
1	(Rizqa, 2024)	Qualitative	The research subjects were MAN 4 Aceh Besar students. This study found that male students have better spatial mathematical ability than female students. Male students think about space more quickly and precisely, while female students take longer to be careful and thorough.
2	(Indyastuti et al., 2024)	Quantitative	The research subjects were 64 students of SMA Negeri 1 Cangkringan class XI Social Sciences. The results showed that gender has no significant effect on spatial ability in learning geography map reading material.
3	(Erfansyah et al., 2023)	Qualitative	The research subjects used were students in one of the junior high schools in Bener Meriah District, Aceh Province. The results showed that male students' spatial abilities included five abilities: space perception, space visualization, mental rotation, space relationships, and space orientation. However, female students only had four abilities because they did not fulfill the mental rotation indicator.
4	(Maulid, 2023)	Qualitative	The research subjects used were three male students and three female students in class V SDN Muncul 03. The results showed that when working on cube space building problems, female students did not fulfill all indicators of spatial ability like male students. The indicators achieved by male students are 1) imagining; 2) Conceptualization; 3) Problem solving; 4) Determining patterns. Meanwhile, female students only achieved the indicators of imagining and conceptualizing.

5	(Maghfiroh, 2023)	Qualitative	The research subjects used were fifth grade students of SDN Wilangan Sambit Ponorogo. The results showed the fact that in the aspect of visualization of space, male students dominated compared to female students. In addition, the researcher also mentioned the factors that influence the differences in spatial abilities between male and female students, which are classified into two categories, namely: (1) biological factors and (2) socio-cultural factors.
6	(Kifthiyyah et al., 2023)	Qualitative	The research subjects were students of class VIII of Al-Irsyad Banyuwangi Junior High School. Based on the research results, it can be seen that the visual spatial abilities of female students are lower because they fulfill only four of the five indicators, while male students are superior because they fulfill all indicators.
7	(Hidayanti et al., 2023)	Quantitative	The research subjects were 70 students of class X IPS SMAN 1 Lawang. The results showed that female students received higher grades than male students due to the fact that female students are more thorough and careful in doing assignments, as well as remembering detailed information for a longer amount of time.
8	(Nurfadila & Mujib, 2023)	Qualitative	The research subjects were students of SMP Swasta Darul Aman class VIII. The results showed that the spatial abilities between female and male students were not much different. Male students tend to be hasty in solving problems, while female students are more careful and thorough. However, male students are also more capable of painting imagination.
9	(Suparmi, et al, 2022)	Qualitative	The research subjects were junior high school students who had equal mathematical abilities. It was found that mentally male subjects were superior in spatial ability when compared to female subjects.
10	(Anggara et al., 2022)	Quantitative	This study used the subject of class X IPS 2 at Madrasah Aliyah (MA) Al-Ittihad. The results showed that the spatial thinking skills of the female group had an average value of 82.2 better than the male group with an average value of 81.
11	(Fasya et al., 2022)	Quantitative	This study used the subjects of grade XI students. The results showed that there was no significant influence between gender on students' geography/spatial thinking. The way men and women think is different according to their different talents or abilities.
12	(Pratiwi, 2022)	Qualitative	The research subjects were 8th grade students of Darul Muwahhidin Islamic Junior High School with visual and kinesthetic learning styles. This study resulted in the finding that male subjects with both visual and kinesthetic learning styles were able to identify spatial relationships while female subjects did not, both female students with visual and kinesthetic learning styles both experienced difficulties in identifying spatial relationships.

13	(Aini & Suryowati, 2022)	Qualitative	This study involved 28 students at MI AL-ASY'ARI Keras Diwek, Jombang. The results showed that males have better visual spatial ability than females, but both have the same ability on the rotation aspect.
14	(Sholihah, 2022)	Qualitative	The results showed that gender has no effect on students of SMP Negeri 1 Puri in solving geometry problems.
15	(Waskito, 2022)	Quantitative	Students in class VII at SMP Negeri 5 Bandar Lampung were the research subjects. The results showed that male students predominantly had good spatial abilities with 42.11%, or 16 people, and female students with 44.74%, or 17 people.
16	(Prasetya, 2021)	Qualitative	The research subjects used were class X students in one of the high schools in Cianjur City. The results showed that in the spatial perception, spatial relation and spatial orientation components, both genders showed high category spatial abilities. Female students' spatial visualization ability is superior to male students, but male students excel in the aspect of mental rotation.
17	(Oktaviani, 2021)	Qualitative	This study involved students in class VIII-G of SMP Negeri 14 Tasikmalaya. The findings in this study were that students with male gender visualized more problem solving in the form of spatial images than female students.
18	(Ismi et al., 2021)	Qualitative	Students of SMP Negeri 2 Praya who are in class VIII are the subjects of this study. The results showed that males and females have the same spatial visualization ability. However, male subjects more often solve orientation and spatial relationship problems.
19	(Muslim, 2021)	Qualitative	The research subjects were Banua South Kalimantaan high school students. The results showed that female students fulfill and show variations in the use of spatial intelligence indicators in geometry problems, while in male students there is one indicator of spatial intelligence that is not fulfilled, namely the ability to connect between data and concepts owned.
20	(Amalliyah et al., 2021)	Qualitative	This study involved high school students. The results showed that female students were better able to think geometrically than male students from a spatial perspective.
21	(Alimuddin & Ms, 2019)	Qualitative	The research subjects used were students of class XI SMA Negeri 2 Pangkep. The results showed that male subjects mostly implemented their spatial skills and logical reasoning when solving geometry-related problems about the frame of reference, while female students used both simultaneously.
22	(Narpila, 2019)	Quantitative	The researcher used grade X students at SMA YPK Medan as the research subjects. The results of this study show that men have better spatial ability than women.

23	(Yuan et al., 2019)	SLR	Males outperformed females in both large-scale and small-scale spatial ability in studies 1 and 2. Both studies showed similarities and differences in neural activity, regardless of large-scale or small-scale spatial ability; however, the impact of gender difference was much larger in large-scale spatial ability. As research found that the reason why women perform less well in large-scale spatial abilities is because they are more vulnerable to emotions.
24	(Purborini & Hastari, 2018)	Qualitative	The research subjects used were 4 students of class VIII C SMP Negeri 2 Trenggalek. The result of this study is the fact that the male gender can fulfill all aspects of spatial ability, while the female gender can only fulfill some aspects.
25	(Alimuddin & Trisnowali, 2018)	Qualitative	Grade XI students of SMA Negeri 2 Pangkep were the research subjects. The results showed that males had better spatial abilities when solving geometry and mental rotation problems. Whereas females do not have this ability.
26	(Latifah, 2017)	Qualitative	The subjects in this study were students at SMAN 1 Gedeg. The results showed that gender does not affect students' spatial ability.
27	(Alfarisi, 2017)	Qualitative	The subjects used were students in class X SMA Negeri 1 Jember. The results showed that spatial abilities related to the characteristics of imagination, problem solving, pattern finding, and conceptualization of both male and female students tended to meet the indicators of the questions given.
28	(Prastyo, 2017)	Qualitative	The research subjects used were students of SMP Negeri 1 Balongbendo with high, medium, and low math abilities. The results showed that male and female gender subjects in the high and medium categories both had the ability to fulfill all five components of Maier's spatial ability. On the other hand, students in the low category only fulfilled three of the five components of Maier's spatial ability: space perception, space visualization, and space relationships.
29	(Narpila, 2016)	Quantitative	The research activities carried out on class X students at SMA YPK Medan resulted in findings that between learning and gender on improving spatial abilities and student independence are not related to each other.
30	(Asis et al., 2015)	Qualitative	In this study, the subjects used were class XI SMA Negeri 17 Makassar. The results showed that male students had a greater advantage in spatial ability in terms of frame of reference and mental rotation. In contrast, male and female students used spatial skills and mathematical-logical intelligence in geometry problems involving spatial representation and projective relationships.

Factors In Relation To Gender Differences In Spatial Ability

Some of the factors that influence spatial ability in individuals include: a) Biological Factors: In biological factors, researchers concentrate on hormones and brain development from a biological perspective. People have two hemispheres, the right hemisphere and the left hemisphere. The right hemisphere is responsible for spatial abilities, while the left hemisphere is responsible for speech or verbal abilities. Males have a larger and more developed right brain than females. Males are more spatially dominant than females (Maghfiroh, 2023). b) Socio-Cultural Factors: Spatial ability is influenced by the child's social and cultural environment. This supports Piaget and Inhelder's idea that spatial ability, which is a component of cognition, develops along with the child's cognitive development (Maghfiroh, 2023). Researchers found that males have more opportunities than females to develop their spatial abilities from the perspective of the socio-cultural environment. (Shafi, et al., 2024).c) Cognitive Factors: It is important to study gender differences in the cognitive learning strategies that students use in schools and how this impacts the learning process. Educational policies that consider the cognitive potential of both male and female students, increase their academic achievement and improve the overall learning process are essential to address this issue. Knowledge of the cognitive learning styles between males and females is also important for changing methods in Pakistani schools to improve student achievement. Some researchers have found that male and female students differ in their cognitive preferences and learning methods (Pratiwi, 2022; Shafi, et al., 2024). d) Emotional Factors: Emotional is a driving factor within an individual that can affect the individual's own behavior. This is then the cause of differences in spatial abilities possessed by a person. As research conducted by (Yuan, et al., 2019) found that the reason why women perform less well in large-scale spatial abilities is because they are more vulnerable to emotions.

Research Methods Are Most Commonly Used In These Studies

An analysis of the thirty relevant articles showed the wide variety of research methods used. The analysis showed that 21 articles (70%) used a qualitative approach to gain a better understanding of the participants' experiences and their views on spatial ability. Qualitative methods such as case studies, in-depth interviews and discursive analysis are often used to study the social construction of spatial ability and the factors that influence it.

Another eight articles (27%) used quantitative approaches, which employ instruments such as psychological tests, questionnaires, and experiments to measure spatial ability and identify differences between groups. These quantitative methods allow generalization of the research results to a wider population.

One article (3%) used the Systematic Literature Review (SLR) method to analyze the current literature on the same topic.The SLR method is useful for finding research trends, discovering knowledge gaps, and synthesizing results from various previous studies. The complexity of spatial ability research is shown by the diversity of methods used in this study. The quantitative approach allows the researcher to

generalize the research results, while the qualitative approach allows the researcher to understand more deeply the experiences of the participants.These two methods were combined to provide a deeper understanding of the components that influence spatial ability.

In addition, the research conducted suggests that findings related to gender differences may be influenced by the educational level of the study participants. Most of the studies focused on upper secondary students, so the findings should be generalized with caution to students at lower levels of education.

Main Conclusions From Previous Research On Gender Differences In Spatial Ability

An analysis of 30 studies that met the inclusion criteria revealed interesting patterns regarding gender differences in students' spatial abilities. In general, these studies showed a tendency for males and females to differ in certain aspects of spatial ability. Based on the results of several studies on spatial abilities based on gender differences that have been conducted by previous researchers, the following findings were obtained:

Domination of Spatial Ability in Terms of Gender

To more easily understand which gender dominates in terms of spatial ability can be seen through the following graph 1:

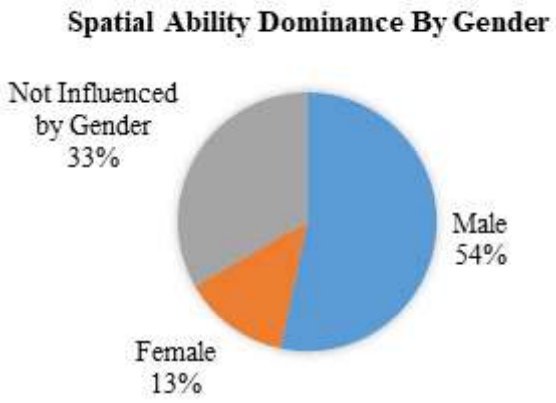

Figure 2. Domination of students' spatial ability based on gender

Level of Education

The level of education can be seen through the sample or research subjects used by researchers starting from the elementary to high school level which is presented in graph 2 as follows:

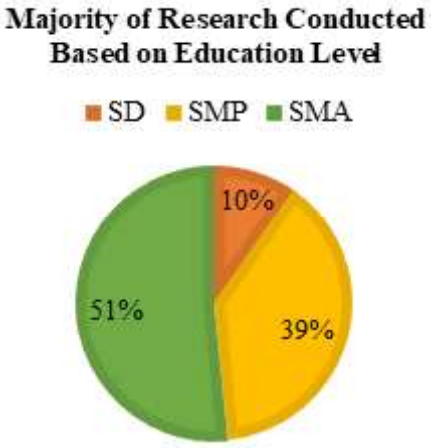

Figure 3. Research by education level

Based on the research results presented in Graph 1, it shows that of the 30 articles that have been reviewed, 54% or 16 of the 30 research articles state that the spatial abilities possessed by men are relatively higher when compared to women. This is because men are good at visualizing image objects that are poured in real life, so this is what causes male students to understand maps and location plans more quickly when compared to female students. While 13% or 4 out of 30 research articles show that female spatial abilities are relatively better when compared to male students due to the fact that in working on problems related to the concept of spatial / spatial female students are more careful and careful. In addition, another 33% or 10 out of 30 research articles show the results that spatial abilities are not influenced by gender differences. This is because all students without exception have the same opportunity in spatial concepts. This means that students' interests and abilities affect their spatial abilities.

Based on the data above, it can be concluded that men dominate when doing

practical activities or direct demonstrations of spatial concepts, while female students dominate when working on spatial-based problems because in working on problems female students tend to be more careful and careful than male students. Figure 1 shows the gender dominance specifically, as follows: Based on Graph 1, it can be seen that in 54% of the studies, male students were found to have an advantage in aspects of spatial ability, such as mental rotation and spatial visualization. However, these findings were not always consistent across studies. This is in line with the findings of a meta-analysis conducted by Voyer (Voyer & Bryden, 1995) which showed small but consistent gender differences in some aspects of spatial ability.

But not all studies show significant differences between men and women. Some studies have found that women may have more attention to detail and visualization in certain situations. Keep in mind that the difference in spatial ability between the sexes is not always deterministic. Their learning style, social environment, and their own cognitive aspects also play an important role.

Another finding in graph 2 shows that from the total number of studies that have been reviewed, it is known that the most research has been conducted at the high school level with the percentage results showing at 51%, followed by the junior high school level at 39% and the least is the elementary school level, which is only 10%. This shows that at the elementary school level, research related to spatial abilities is still minimal and rarely done. Thus from the acquisition of these data makes opportunities for other researchers to conduct research related to spatial abilities at the elementary school level.

In addition, the research conducted suggests that findings related to gender differences may be influenced by the educational level of the study participants. Most of the studies focused on upper secondary students, so the findings should be generalized with caution to students at lower levels of education.

Discussions

The results of this thorough literature review provide a useful understanding of the complex relationship between gender and students' spatial abilities. Some studies show that male students tend to be better in some aspects of spatial ability, especially in terms of mental rotation and space visualization. However, these trends are not consistent across all studies. Each study reviewed showed a significant degree of variability. Certain studies showed that males excelled in spatial ability, but other studies found no significant gender differences. Several things could account for this discrepancy, such as:

1. Differences in Research Methodology: This research utilizes a variety of methodologies. Some are quantitative and qualitative. Quantitative research typically uses standardized tests and statistical analysis to find significant differences between groups. Qualitative research examines the factors, cognitive processes, and strategies that students use in spatial tasks. The diversity of methods may lead to different results.
2. Diversity of Spatial Task: This research investigates different aspects of spatial ability, such as mental rotation, spatial visualization, spatial perception, and spatial orientation (Porat & Ceobanu, 2023). The extent of gender differences may vary depending on the type of tasks performed in a particular place.
3. Influence of Contextual Factors: Age, education level, socio-cultural background, and learning experiences can significantly influence the development and expression of spatial abilities (Ünal et al., 2022; Pratiwi, 2022; Shafi, et al., 2024).

In addition to gender, a number of variables have been identified as significant influences on the ability to interact with space: (1) Learning Experiences, tudies have shown that participating in activities that stimulate spatial thinking, such as playing puzzles, building blocks, and video games, can significantly improve spatial ability in both

males and females (Peterson et al., 2020); (2) Educational Experiences, the use of hands-on activities, manipulatives, and technology-supported learning environments can significantly impact developmental progression; (3) Socio-cultural Factors, cultural norms and expectations can influence the development of spatial skills in both boys and girls. Societal stereotypes and expectations can also affect the types of activities that boys and girls are encouraged to do, which in turn can affect their spatial development (Yuan et al., 2019).

The results of this analysis have significant consequences for educational practice: (1) Teachers should create inclusive learning environments that cater to the diverse learning styles and needs of all students, regardless of gender; (20 An emphasis on Experiential Learning such as incorporating hands-on activities, manipulatives and technology-supported learning experiences into the curriculum can help all students develop spatial skills (Fowler et al., 2022); (3) Addressing gender stereotypes in a way that educators should be mindful of gender stereotypes and actively challenge beliefs about gender differences in spatial abilities; (4) Promoting Spatial Thinking in Multiple Disciplines i.e. spatial thinking ability is not only related to science and math, but also to fields such as language, music and art. All students can gain spatial thinking skills if these activities are incorporated into the curriculum.

Limitations of this review include that the inclusion criteria may have inadvertently excluded relevant studies. In addition, the diversity of research methodologies and various assessment tools make it difficult to make definitive conclusions. Therefore, additional research is needed, such as: (1) Studying the long-term impact of interventions designed to improve spatial ability in males and females; (2) Studying the factors of spatial ability development; (3) Conducting cross-cultural studies to study the influence of cultural factors on gender differences in spatial ability; (4) The results show that research on spatial ability is still rarely done at the elementary school level, therefore research is needed at various levels of education.

CONCLUSION

An analysis of thirty studies shows that gender differences in spatial ability are a complex phenomenon. This systematic literature review provides a comprehensive overview of recent research on gender differences in students' spatial ability. Some previous studies suggest that male students may have an advantage in some aspects of spatial ability, but the findings are inconsistent and influenced by many factors. This analysis emphasizes the importance of considering individual differences and providing equitable learning experiences by involving various populations, using a variety of research techniques, and considering broader contextual components to gain greater understanding.

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