PRISMA, 15(1), 48-57, June 2026
https://jurnal.unsur.ac.id/prisma
DOI:10.35194/jp.v15i1.5989

p-ISSN 2089 3604
e-ISSN 2614 4611

Spatial Ability of Grade VIII Students in Terms of Van Hiele's Level of Thinking

Sabila Mukhlishonisa [1,*] , Al Jupri [2] , Jarnawi Afgani Dahlan [3]
[1,2,3] Universitas Pendidikan Indonesia, Bandung
*Corresponding Authors: sabilamukh@upi.edu

Submitted: *10-01-2026*	*Revised*: *12-01-2026*	*Accepted*: *17-01-2026*	*Published: 05-06-2026*

ABSTRACT

Spatial ability is important in learning geometry, especially related to 3D shapes. This study aims to analyze students' spatial ability based on van Hiele's geometry thinking level. The research was conducted with a qualitative case study approach involving 23 students of grade VIII at one of the public junior high schools in Bandung, West Java. The researchers gave two types of tests to students, namely spatial tests based on spatial perception, visualization, mental rotation, spatial relation, and spatial orientation elements, as well as geometry thinking tests based on van Hiele's five levels of thinking, namely visualization, analysis, informal deduction, deduction, and rigor. The results show that about half of students reached the visualization level with low spatial orientation ability, while the rest of students have not reached the visualization level with very low spatial orientation ability. The spatial ability of students in the spatial perception element is categorized as high, in the visualization and spatial relation elements is categorized as sufficient, and in the mental rotation element is categorized as low. Students' ability to see objects from various directions and to rotate objects still needs to be improved.

Keywords: geometry education; spatial ability; van Hiele

INTRODUCTION

Spatial ability is one of the important abilities needed by every person. Spatial ability is useful in various activities in everyday life, especially for those who work in computer-graphics, engineering, architects, interior design, chemistry, geology and so on (Ishikawa & Newcombe, 2021; Subroto, 2012). Besides that, spatial ability can affect a person's intellectual intelligence in addition to verbal ability and numerical ability (Linn & Petersen, 1985; Wai et al., 2009). National Academy of Science also states that the mathematical abilities that students must have include skills in combining aspects of space, representation, and reasoning processes (Adam & Zulkarnaen, 2019). The skill in combining these spatial aspects is included in spatial ability. As stated by Sipus and Cizmesija (2012) that spatial ability is an intuition about shapes and the relationships between them. There are 5 elements of spatial ability divided by Maier (1998), namely spatial *perception*, *visualization*, *mental rotation*, spatial *relation,* and *spatial orientation*. The results of previous studies show that students who have high spatial ability will have better performance in lessons, scientific reasoning, and creative thinking, especially in learning math geometry material (Atit et al., 2020; Chao & Liu, 2016; Mananeke et al., 2017). Therefore, it is important for someone to have good spatial ability.

There are students that still have low spatial ability. Research of Kariadinata, Yaniawati, Juariah, Susilawati, and Cahyana (2019) obtained the initial results of the spatial ability test with the highest score of 50 and the lowest score was 15, and the average score was 43.18 (on a scale of 100). In addition, Hutagalung, Sinaga, and Syahputra (2021) research reinforces that 15 out of 23 students still have low spatial ability. This shows that the spatial ability of most students is still low.

Low spatial ability can affect students in solving geometry-related problems. There are still students who have difficulty when working on problems related to spatial orientation (Adam & Zulkarnaen, 2019). Students who have low spatial ability do not understand the geometry material, so they cannot connect the properties of space shapes, connecting objects with others in a form of flat side space shapes (Hutagalung et al., 2021). Though one of the spatial ability, visualization, can help students to understand and simplify the problem in learning geometry materials (Alghadari & Herman, 2018). So, spatial ability helps students in learning and solving problem about geometry.

When learning geometry, students go through van Hiele's stages of thinking. There are five stages of geometry thinking stated by van Hiele, namely level 0 (visualization), level 1 (analysis), level 2 (informal deduction), level 3 (deduction), and level 4 (rigor) (Crowley, 1987; Hiele, 1999; Sudihartinih & Wahyudin, 2019; VanHiele, 1959). Students who have low achievement in solving geometry problems because students are not accustomed to solving these types of problems, weaknesses in remembering prior knowledge, and lack of problem solving frameworks (Rusyda et al., 2017). Student errors can be divided into 3 categories, namely type err1 due to slips or small errors, type err2 due to conceptual errors, and type err3 due to procedural errors (Makhubele, Nkhoma, & Luneta, 2015; Sudihartinih, 2018). Therefore, this research aims to identify students' spatial ability based on the achievement of students' geometry thinking stages. Then also analyzed if there are errors that students make in solving spatial geometry-related problems, and what factors cause students to be wrong in answering these questions.

RESEARCH METHODS

This study used a qualitative approach with a case study research type to analyze the spatial ability of 23 grade VIII students at one of the public junior high schools in Bandung City, West Java consisting of 14 girls and 9 boys. Data collection activities were carried out using triangulation data, namely tests, interviews, and theories.

The test was conducted by giving 25 multiple choice questions of van Hiele geometric thinking adapted from Usiskin (1982) and 15 multiple choice questions which were divided into three questions per element of Maier's spatial ability. The test was conducted online using *google forms* and lasted for 1 hour.

RESULTS AND DISCUSSION

The results of the van Hiele geometry thinking test showed that of the 23 students who took the test, 12 students were categorized into level pre 0 and 11 other students were categorized into level 0. Students who categorized into pre 0 level does not reach standard of level 0 category.

Based on research by van Hiele students cannot advance to a higher level (level n) without passing through a lower level (level n-1) (Sudihartinih & Mulyana, 2014). It means pre 0 level students still cannot name, compare, and operate geometric figures perfectly according to its appearance. At level 0, if there is a slight change in the shape, students will see it as a different shape. For example, a square if its position is rotated 45° from vertical, students may see it as a rhombus, no longer a square (Walle, 2007). This students' category level of geometry thinking a bit different from some studies that junior high school students only reach level 0 to level 2 in van Hiele's theory (Muhassanah et al., 2014; Sofyana & Budiarto, 2013). These results showed that students' level of geometry thinking still very low.

Then for the results of the spatial ability test after calculating the average percentage of spatial ability of students at level pre 0 per indicator according to the criteria for the level of spatial ability according to Hafizin (2017). The results are shown in Table 1.

Table 1. Category of Students' Spatial Ability

Elements of Spatial Ability	Average Percentage of Pre 0 Level Student Ability	Pre 0 Level Student Ability Category	Average Percentage of Level 0 Student Ability	Level 0 Student Ability Category
Spatial perception	66,67%	High	63,64%	High
Visualization	50%	Sufficient	42,42%	Sufficient
Mental rotation	27,78%	Low	33,33%	Low
Spatial relation	41,67%	Sufficient	51,51%	Sufficient
Spatial orientation	19,44%	Very low	27,27%	Low

Based on Table 1 that the spatial perception ability of pre 0 level students and level 0 students is in the high category, meaning that students are able to observe well the condition of an object placed in a vertical or horizontal position. Then for the ability of visualization and spatial relation, pre 0 level students and level 0 students are categorized as sufficient, meaning that students are quite capable of visualizing the displacement or change in the parts of an object and quite understand the form of an object or the relationship between one part and another. Then for *mental rotation* ability, pre 0 and level 0 students are categorized as low, meaning that students are not yet able to mentally rotate a two-dimensional or three-dimensional building. And the category for *spatial orientation* ability for pre 0 level students is very low, meaning that pre 0 level students have not been able to orient an object in various points of view, while for level 0 students get a low category, meaning that level 0 students are not sufficiently able to orient an object in various points of view.

The difference in this achievement of students' spatial geometry skills is in accordance with what is explained by Sulistiowati, Herman, and Jupri (2019) that solving geometry-related problems will differ between students at each level of geometry thinking, students with lower levels of geometry thinking will have more difficulty than students who are at higher levels of geometry thinking. This can also be seen from the results that in the spatial orientation ability of pre 0 level students is lower than the spatial orientation ability of level 0 students.

In general, the spatial geometry skills of eighth-grade students remain limited, as indicated by interviews with mathematics teachers showing that only one or two students demonstrate strong spatial abilities. This condition is closely related to students' weak reasoning skills, which hinder their understanding of spatial concepts. Since spatial ability requires adequate reasoning processes, spatial representations, and conceptual understanding (Adam & Zulkarnaen, 2019)), insufficient reasoning inevitably affects students' spatial performance. Consistent with this, Susilawati and Suhendra (2025) found that students with lower initial abilities tend to rely on imitative and procedural reasoning, emphasizing the need for learning approaches that strengthen students' reasoning to support the development of spatial geometry skills.

Based on the students' test results, there are several errors that can be categorized into err1 type, err2 type, and err3 type errors, according to the categorization of errors by Makhubele, Nkhoma, and Luoleh (in Sudihartinih, 2018). Err1 (*slip*) type errors were made by students including S5 because they clicked the wrong answer option due to not focusing when working.

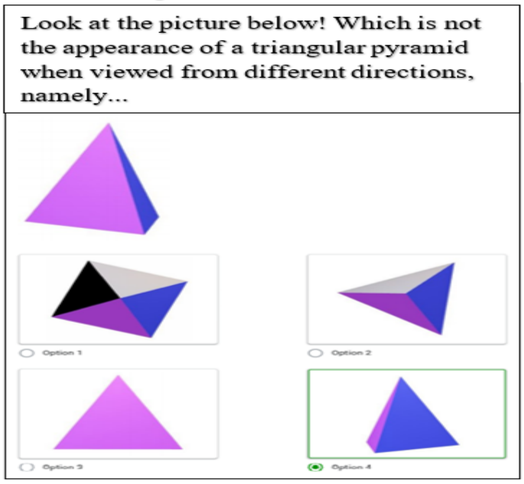

Figure 1. Example of Error 1 Type by S21

In addition, students were not careful in reading the problem, as in Figure 1. Students did not read the word "not" in the problem. So instead, they chose a shape that was similar to the one in the question.

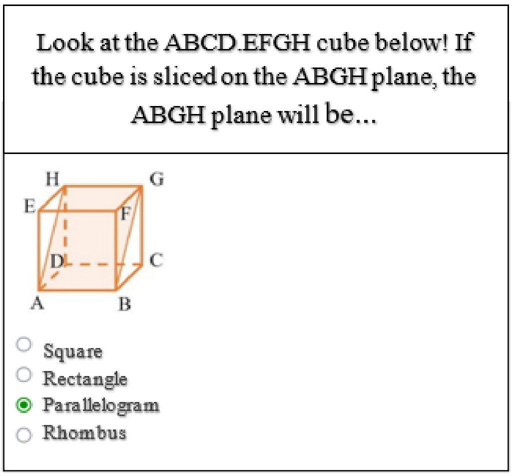

Figure 2. Example of Error 2 Type Error by S13

Then the error type error2 (concept error) made by students including by S13 as in Figure 2 because students do not understand the diagonal plane of the cube so that they only. Answer based on direct observation of the image in the problem, this is in accordance with the achievement of geometric thinking level which only reaches level 0.

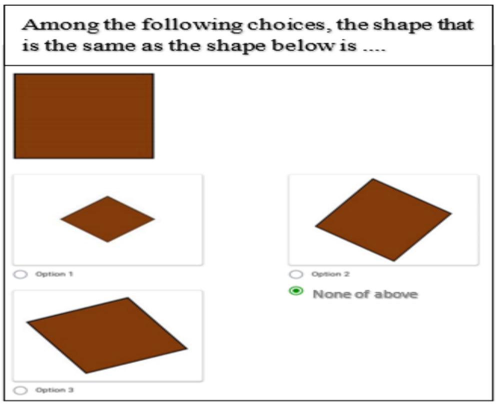

Figure3. Example of Err2 Type Error by S1

In addition, S1 also answered the problem as in Figure 3 because he could not mention the name of the shape in the problem correctly and did not see that option 2 was the same type of shape as the one in the problem.

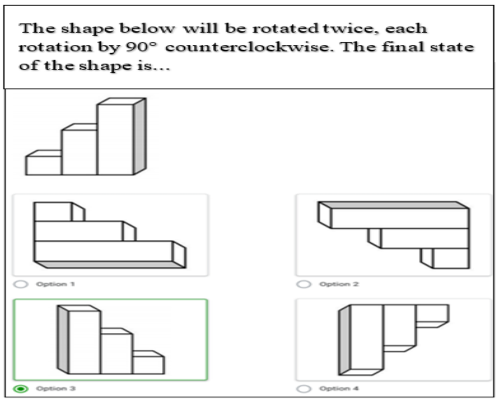

Figure 4. Example of Err2 Type Error by S17

Then for the problem as in Figure 4, it was not answered correctly by S17 because S17 did not understand the degree of angle, so he only rotated the object without paying attention to the degree of rotation.

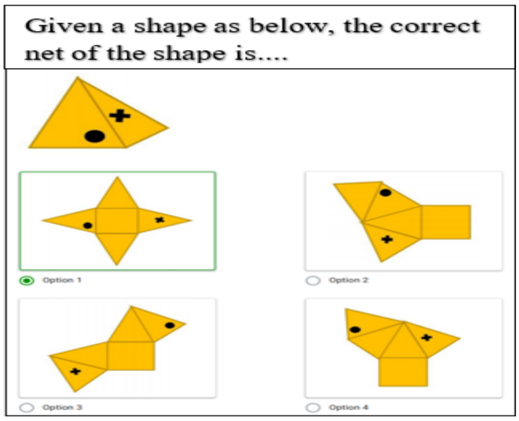

Figure5. Example of Err2 Type Error by S14

Then S14 made an error type err2 in the problem as in Figure 5 because he answered based on limited knowledge of the shape of the quadrilateral pyramid net, so he chose a net that looked familiar without paying attention to the location of the marks on both sides of the pyramid.

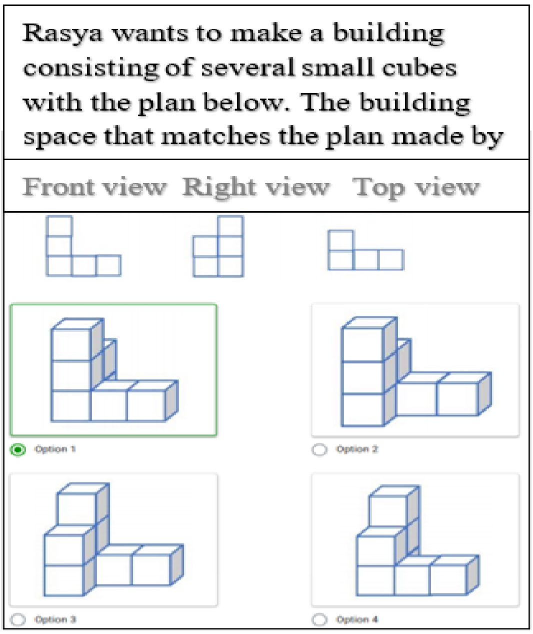

Figure 6. Example of Err2 Type Error by S19

Another example is the mistake made by S19 regarding the construction of the building based on the front, right, and top views as in Figure 6. S19's lack of skills in constructing the building caused him to answer the question incorrectly.

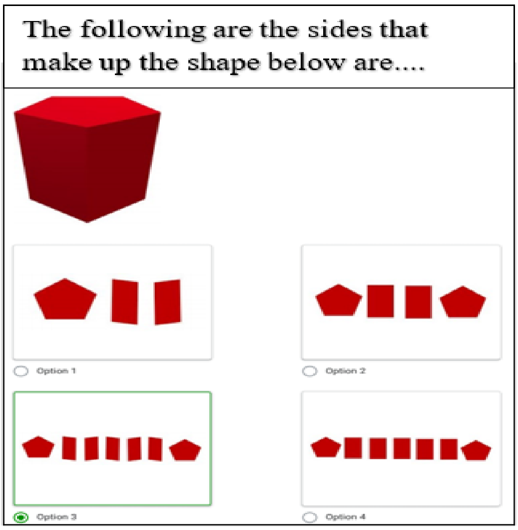

Figure 7. Example of Err2 Type Error by S14

Furthermore, the error type err3 was made by S18 in answering the question as in Figure 7 because he did not apply the understanding he had gained about the net of a pentagonal prism to answer the question. S18 answered based on direct observation of the shape of the shape in the problem without paying attention to what flat shapes build the upright side of the prism. This is also in accordance with his van Hiele geometry level of thinking which only reaches level 0 which pays attention to the shape of the shape without paying attention to the properties of the shape.

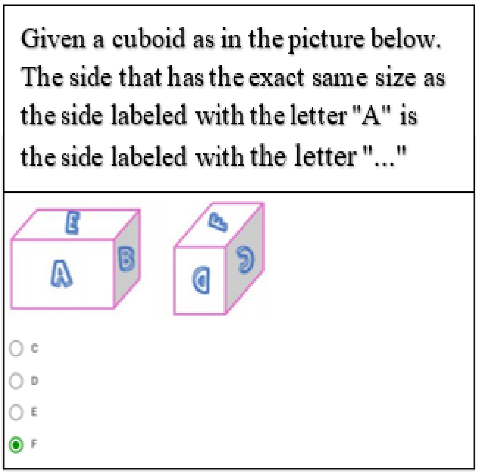

Figure 8. Example of Err3 Type Error by S1

In addition, error type err3 was made by S1 in answering the question as in Figure 8, where S1 was wrong in choosing the side of the beam with the exact same size as the side asked in the question. Even though when asked again about which pairs of sides are facing, S1 has answered correctly.

Based on the errors made by students according to the classification of errors according to Makhubele, Nkhoma, and Luneta (in Sudihartinih, 2018) above, it is known that the factors that cause student errors are divided into internal and external factors. Internal factors from students, namely from err1 type errors that students' readiness in answering questions that affect student focus, from err2 and err3 type errors that students' understanding of geometry concepts and students' ability to imagine geometric shapes along with changes in conditions on the plane are still not good so that students are still not precise in answering questions.

In addition, the level of van Hiele geometry thinking achieved by students who only reach the pre 0 level and level 0 also affects the spatial thinking process of students. Students with pre 0 level of van Hiele geometry have more difficulties when working on problems than students with level 0 of van Hiele geometry, as mentioned in the article. Sulistiowati, Herman, & Jupri (2019) that the difficulties faced by students with lower levels of geometry are more than the difficulties faced by students with higher levels of geometry thinking. Students' experience is also a factor, not all students have ever worked on problems similar to those given by the researchers, in learning the teacher rarely gives problems that focus on all spatial elements, only problems related to the net of a space that has been given to students.

While the external factors are environmental conditions when students get flat-sided geometry material enforced distance learning affects the understanding gained by students, so there are still many students who are wrong in answering spatially related questions. That condition also affects students' focus in solving spatial test. Students say they understand the materials better if explained directly by the teacher compared to finding their own concepts. Whereas one of the 21st century learning principles should use a student-centered learning approach (Zubaidah, 2016). But students are still not used to that learning approach. So, because of students' understanding of geometry material is still lacking, it causes students' difficulty in answering questions related to spatial geometry.

CONCLUSION

The spatial ability of students based on van Hiele's geometry level of thinking is for spatial perception ability has reached a high category, for visualization and spatial relation ability is categorized as sufficient, for mental rotation ability is still low. As for spatial orientation ability, it is different between pre level 0 students and level 0 students, where the ability of level 0 students is categorized as low and the ability of pre level 0 students is still very low.

The errors made by students include err1 type errors (slip) due to errors in answering, err2 type errors due to students' lack of understanding and skills regarding spatial, and err3 type errors because students have not applied their understanding of geometry material to answer spatial questions.

The factors that cause these errors are students' lack of readiness and experience in solving spatial problems, lack of students' and understanding, and students' van Hiele geometry thinking level. While the external factor is the condition of distance learning so that the understanding gained by students is not intact.

Future research is expected to make instruments with real objects related to spatial problems and do the research about methods and learning strategies to improve spatial ability effectively.

REFERENCES

Adam, M. B., & Zulkarnaen, R. (2019). Studi Kasus Kemampuan Spasial Siswa Kelas IX dalam Menyelesaikan Soal TIMSS pada Materi Geometri. *Prosiding Seminar Nasional Matematika Dan Pendidikan Matematika Sesiomadika 2019*, 749–753.

Alghadari, F., & Herman, T. (2018). The obstacles of geometric problem-solving on solid with vector and triangle approach. *Journal of Physics: Conference Series*, *1132*(1). https://doi.org/10.1088/1742-6596/1132/1/012046

Atit, K., Power, J. R., Veurink, N., Uttal, D. H., Sorby, S., Panther, G., Msall, C., Fiorella, L., & Carr, M. (2020). Examining the role of spatial skills and mathematics motivation on middle school mathematics achievement. *International Journal of STEM Education*, *7*(1). https://doi.org/10.1186/s40594-020-00234-3

Chao, J. Y., & Liu, C. H. (2016). A Case Study on The Spatial Conceptualization Abilities for Sixth Grade Elementary Students from Urban, Suburban and Remote Schools. *EURASIA Journal of Mathematics Science and Technology Education*, *13*(6), 1675–1686.

Crowley, M. (1987). The van Hiele model of the development of geometric thought. *Learning and Teaching Geometry, K-12*, 1–16.

Hafizin, M. Al. (2017). *Analisis Kemampuan Spasial Siswa pada Geometri Kudus dan Balok di Kelas IX SMP Negeri 03 Pulau Beringin*. Universitas Muhammadiyah Palembang.

Hiele, P. Van. (1999). Developing Geometric Thinking through Activities That Begin with Play. *Teaching Children Mathematics*, *6*(February 1999), 10–16.

Hutagalung, D. H., Sinaga, B., & Syahputra, H. (2021). Spatial Ability Analysis of Students in Applying the Van Hiele Theory with Autograph Media Assisted. *Journal of Education and Practice*, *12*(2), 54–58. https://doi.org/10.7176/jep/12-2-07

Ishikawa, T., & Newcombe, N. S. (2021). Why spatial is special in education, learning, and everyday activities. *Cognitive Research: Principles and Implications*, *6*(1). https://doi.org/10.1186/s41235-021-00274-5

Kariadinata, R., Yaniawati, R. P., Juariah, J., Susilawati, W., & Cahyana, A. (2019). Mathematical spatial and disposition ability through the wingeom application. *Journal of Physics: Conference Series*. https://doi.org/10.1088/1742-6596/1402/7/077098

Linn, M. C., & Petersen, A. C. (1985). Emergence and Characterization of Sex Differences in Spatial Ability: A Meta-Analysis. *Child Development*, *56*(6), 1479–1498.

Maier, P. H. (1998). *Spatial Geometry and Spatial Ability - How To Make Solid Geometry Solid?* University of Osnabrueck.

Makhubele, Y., Nkhoma, P., & Luneta, K. (2015). *Errors Displayed by Learners in The Learning of Grade 11 Geometry* (Issue October). https://doi.org/10.13140/RG.2.1.1534.8565

Mananeke, S. G., Wenas, J. R., & Sambuaga, O. T. (2017). Hubungan Kecerdasan Visual-Spasial dengan Hasil Belajar Matematika Siswa pada Materi Geometri. *Jurnal Sains, Matematika, & Edukasi (JSME) FMIPA Unima*, *5*(1), 87–91.

Muhassanah, N., Sujadi, I., & Riyadi, R. (2014). Analisis Keterampilan Geometri Siswa dalam Memecahkan Masalah Geometri Berdasarkan Tingkat Berpikir Van Hiele. *Jurnal Elektronik Pembelajaran Matematika*, *2*(1).

Rusyda, N. A., Kusnandi, K., & Suhendra, S. (2017). A Cognitive Analysis of Students' Mathematical Communication Ability on Geometry. *Journal of Physics: Conference Series*, *895*(1). https://doi.org/10.1088/1742-6596/895/1/012083

Sipus, Z. M., & Cizmesija, A. (2012). Spatial Ability of Students of Mathematics Education in Croatia Evaluated by The Mental Cutting Test. *Annales Mathematicae et Informaticae*, *40*, 203–216.

Sofyana, A. U., & Budiarto, M. T. (2013). Profil Keterampilan Geometri Siswa SMP dalam

Memecahkan Masalah Geometri Berdasarkan Level Perkembangan Berpikir Van Hiele. *Jurnal Elektronik Matematik*, *2*(1).

Subroto, T. (2012). Kemampuan Spasial (Spatial Ability). *Seminar Nasional Pendidikan Matematika "Pengembangan Keterampilan Berpikir Serta Pembinaan Karakter Melalui Pembelajaran Matematika,"* 252–259.

Sudihartinih, E. (2018). Analisis Kesalahan Siswa dalam Konsep Titik dan Garis pada Bidang. *Erudio Journal of Educational Innovation*, *5*(1), 12–18. https://doi.org/10.18551/erudio.5-1.2

Sudihartinih, E., & Mulyana, E. (2014). Perkuliahan Geometri Transformasi dengan Pendekatan Konstruktivisme untuk Meningkatkan Level Berpikir Geometri van Hiele. *Jurnal Pendidikan Matematika Sigma Didaktika*, *3*(1), 11–16.

Sudihartinih, E., & Wahyudin. (2019). The van Hiele Levels of Geometric of Students in First Semester Reviewed from Gender. *Journal of Physics: Conference Series*, *1280*(4). https://doi.org/10.1088/1742-6596/1280/4/042034

Sulistiowati, D. L., Herman, T., & Jupri, A. (2019). Student difficulties in solving geometry problem based on Van Hiele thinking level. *Journal of Physics: Conference Series*, *1157*(4). https://doi.org/10.1088/1742-6596/1157/4/042118

Susilawati, I., & Suhendra, S. (2025). An Experimental Study on the Achievement and Enhancement of Eighth Grade Students' Creative and Imitative Reasoning through Resource-Based Learning in Mathematics. *Prisma*, *14*(1), 25. https://doi.org/10.35194/jp.v14i1.5115

Usiskin, Z. (1982). Van Hiele Levels and Achievement in Secondary School Geometry. *CDASSG Project The University of Chicago*.

VanHiele, P. M. (1959). The Child's Thought and Geometry. In *English Translation of Selected Writings of Dina van Hiele-Geldof and Pierre M. van Hiele* (pp. 243-252 (in 'Classics')).

Wai, J., Lubinski, D., & Benbow, C. P. (2009). Spatial ability for STEM domains: Aligning over 50 years of cumulative psychological knowledge solidifies its importance. *Journal of Educational Psychology*, *101*, 817–835. https://doi.org/10.1037/a0016127

Walle, J. A. Van de. (2007). *Matematika Sekolah Dasar dan Menengah Jilid 2* (G. Sagara & Lemeda Simarmata (eds.); 6th ed.). Erlangga.

Zubaidah, S. (2016). *Keterampilan Abad Ke-21: Keterampilan yang Diajarkan Melalui Pembelajaran*. *2*, 1–17.