M A T H L I N E
JURNAL MATEMATIKA DAN PENDIDIKAN MATEMATIKA
ISSN 2502-5872 (Print)
ISSN 2622-3627 (Elektronik)

This is an open access article under the CC BY-SA license

Volume 11 Number 4, November 2026, 975-984

IDENTIFICATION OF STUDENTS' GEOMETRIC THINKING LEVELS BASED ON VAN HIELE THEORY

Tika Karlina Rachmawati[1], Rifa Rizqiyani[2], Muhamad Rakha Priyo Utomo[3], Ridho Mudjib[4]

[1, 2, 3, 4] Program Studi Pendidikan Matematika, UIN Sunan Gunung Djati Bandung, West Java, Indonesia

*Correspondence: tikakarlinarachmawati@uinsgd.ac.id

Received 27 August 2026; Revised 1 October 2026; Accepted 7 October 2026

ABSTRACT

A precise diagnosis of pre-service teachers' geometric reasoning is crucial to address the persisting gap between complex coursework demands and students' actual cognitive readiness. Therefore, this study aims to identify, describe, and analyze the geometric thinking levels of mathematics education students based on the Van Hiele Theory framework. This study employed a descriptive quantitative approach. The participants were 108 mathematics education students selected through purposive sampling. Data collection was carried out using the Van Hiele Geometry Test (VHGT) instrument and analyzed using descriptive statistics to calculate the frequencies and percentages of level attainment. The results showed that the majority of students' geometric thinking abilities were still dominated by basic levels. The detailed achievements indicate that 4.63% of students did not meet the criteria, 22.22% were at Level 0 (Visualization), 23.15% at Level 1 (Analysis), 12.96% at Level 2 (Informal Deduction), 2.78% at Level 3 (Formal Deduction), and only 1.85% reached Level 4 (Rigor). Furthermore, a crucial finding revealed a high proportion of students in the No Fit category at 32.41%, indicating an anomaly of inconsistent geometric reasoning and non-sequential mastery, where students succeeded in advanced tasks but failed basic prerequisites. Based on these findings, it is concluded that a gap exists between the complex demands of geometry coursework and the reality of students' cognitive structures. Therefore, future intervention research is recommended to design and implement gradual learning strategies through scaffolding techniques to bridge the development of students' deductive reasoning hierarchically and meaningfully.

Keywords: Geometric Thinking, Van Hiele Theory, Prospective Mathematics Teachers, Cognitive Profile, Scaffolding.

How to Cite: Rachmawati, T. K., Rizqiyani, R., Utomo, M. R. P., & Mudjib, R. (2026). Identification of Students' Geometric Thinking Levels Based on Van Hiele Theory. *Mathline: Jurnal Matematika dan Pendidikan Matematika, 11*(4), 975-984. http://doi.org/10.31943/mathline.v11i4.1227

PRELIMINARY

Geometry is a fundamental area of study in mathematics that plays a crucial role in developing logical reasoning and spatial skills (Nabila et al., 2025). Given this importance, the development of robust geometric thinking abilities becomes a primary objective in mathematics education. At the higher education level, students, particularly pre-service

mathematics teachers, are expected to possess strong deductive reasoning and the ability to systematically construct geometric proofs (Khomeni et al., 2025). Specifically, the mastery of geometry at this stage requires a high level of cognitive proficiency in understanding geometric constructions and spatial reasoning (Maryono & Sobarningsih, 2024), Therefore, identifying students' geometric thinking levels based on the Van Hiele theory is a crucial step for systematically mapping and evaluating their cognitive understanding.

Although mastering geometry is essential for student competency, academic reality demonstrates that many pre-service mathematics teachers still exhibit low-level or highly inconsistent geometric thinking abilities (Ramadan et al., 2026). Various studies reveal that fundamental misconceptions in geometry are still frequently found among pre-service mathematics teachers (Purwaningrum & Purwoko, 2024). These difficulties become increasingly evident when students are required to solve problems demanding high levels of abstraction, such as determining coordinate points in three-dimensional space (Fitri & Refnywidialistuti, 2025) or solving analytic geometry proofs (Panglipur, 2022). Such cognitive obstacles indicate a misalignment between the complex demands of the course materials and the actual geometric reasoning structures possessed by the students.

The cognitive deficit among pre-service mathematics teachers is particularly alarming because an educator's geometric reasoning directly dictates their pedagogical capacity (Samudra et al., 2025). According to the foundational postulates of the Van Hiele theory, teachers cannot effectively guide students to achieve a higher cognitive level if they themselves have not fully mastered the reasoning structures of that specific tier (Ramadan et al., 2026). Consequently, pre-service teachers trapped at the visualization or analysis levels will likely reduce complex geometric instruction in their future classrooms to mere procedural memorization, thereby perpetuating a cycle of low spatial literacy among future generations of students.

To systematically analyze these cognitive issues, the Van Hiele Theory offers a highly relevant diagnostic framework due to its advantage in providing a structured, hierarchical lens to accurately evaluate the developmental progress of a student's geometric reasoning quality (Silmi & Muiz, 2022). This theory maps an individual's geometric reasoning development into five hierarchical levels, ranging from visualization, analysis, informal deduction, formal deduction, to rigor (Van Hiele, 1986). While identifying students' Van Hiele thinking levels serves as a crucial assessment step (Wicaksono & Juniati, 2022), a significant research gap remains. Previous studies utilizing the Van Hiele framework have predominantly focused on primary and secondary school students.

Furthermore, existing research involving pre-service teachers typically restricts its analysis to standard hierarchical categorization, often overlooking the critical presence of anomalous cognitive patterns within the cohort.

To fully comprehend the hierarchical nature of this framework, Palobo et al. (2026) delineate the operational characteristics of each cognitive tier. At Level 0 (Visualization), students identify geometric shapes holistically based solely on their visual appearance, without recognizing the underlying mathematical properties. The transition to Level 1 (Analysis) is marked by students' ability to identify and describe the specific properties of a shape, although they still perceive these properties as isolated entities. Upon entering Level 2 (Informal Deduction), the capacity to construct logical relationships and establish hierarchies among various geometric properties begins to emerge. Furthermore, Level 3 (Formal Deduction) requires students to independently construct mathematical proofs while profoundly understanding the roles of axioms, definitions, and theorems. The pinnacle of this hierarchy is Level 4 (Rigor), representing the highest cognitive tier where students are highly capable of comprehensively analyzing and comparing diverse axiomatic systems, including non-Euclidean geometries.

The emergence of anomalous cognitive patterns, frequently categorized as the “No Fit” group, indicates a fundamental disruption in the sequential learning process. This phenomenon frequently stems from mechanical rote learning strategies deeply entrenched during the students' prior secondary education (Safitri et al., 2026). Instead of internalizing logical connections and spatial relationships, students tend to merely memorize geometric formulas and procedural steps to pass examinations. Consequently, when confronted with a comprehensive diagnostic assessment, they may coincidentally guess or mechanically solve complex abstract problems while failing the foundational visual or analytical prerequisites. This condition results in a pseudo-cognitive leap that ultimately undermines the hierarchical architecture of Van Hiele's thinking levels.

Without an accurate initial diagnosis that accounts for both hierarchical progression and cognitive inconsistencies, instructional interventions run the risk of being misdirected (Renanda et al., 2023). Therefore, this study fills the existing gap by not only mapping the standard geometric thinking levels of pre-service mathematics teachers but also specifically uncovering and analyzing the "No Fit" phenomenon. This phenomenon is defined as a condition in which students exhibit non-sequential mastery by succeeding in advanced tasks while failing foundational prerequisites. By revealing this anomaly, this study provides a novel diagnostic contribution regarding the cognitive vulnerabilities of

future educators. Driven by this academic urgency, this study aims to identify, describe, and analyze the geometric thinking levels and anomalous cognitive patterns of mathematics education students based on the Van Hiele Theory framework.

METHODS

This study employed a descriptive quantitative research design. The selection of this design aligns with the primary objective of the study, which is to systematically map, describe, and analyze students' geometric thinking stages using numerical data, frequencies, and percentages derived from test scores, without applying any specific treatment or variable manipulation.

The initial population in this study comprised 115 pre-service mathematics teachers enrolled in a specific course within the same academic cohort. The selection of this specific group was conducted purposively based on the consideration of uniformity in their academic experiences, curriculum, and the learning materials they had received. From this initial population, the final sample was reduced to 108 subjects. The specific criterion for exclusion was student attendance; 7 students were excluded from the final analysis because they were absent during the administration of the diagnostic test.

Data collection was conducted using the Van Hiele Geometry Test (VHGT) instrument adopted from Usiskin (1982). This diagnostic instrument consists of 25 multiple-choice questions designed to classify students' cognitive stages. The items are evenly distributed, with exactly five questions representing each of the five hierarchical Van Hiele levels: visualization (Level 0), analysis (Level 1), informal deduction (Level 2), formal deduction (Level 3), and rigor (Level 4).

The scoring procedure and level assignment strictly followed the hierarchical principles of the Van Hiele theory. To achieve mastery at a specific level, a student was required to correctly answer a minimum of 3 out of the 5 items corresponding to that level. Consequently, students were classified into Levels 0 through 4 based on their highest attained level of sequential mastery. Furthermore, two additional categorizations were established: the "Did Not Meet" category was assigned to students who failed to achieve the minimum mastery criterion (less than 3 correct answers) even at the most basic stage (Level 0). Conversely, the "No Fit" category was assigned to students who exhibited anomalous response patterns, such as successfully mastering a higher level (e.g., Level 2) while failing to master a foundational prerequisite level (e.g., Level 0 or 1), thereby

violating the theoretical hierarchy. The collected data were then analyzed using descriptive statistics to calculate the frequencies and percentages of level attainment within the cohort.

Prior to data collection, appropriate ethical considerations were implemented. Informed consent was obtained from all participating students, ensuring their willingness to participate and the confidentiality of their test results. Additionally, official institutional permission to conduct the study was granted by the mathematics education study program.

RESULT AND DISCUSSION

Based on the stages of the designed descriptive quantitative research method, data collection was conducted to map students' geometric thinking levels in depth without any additional treatment manipulation. Through the data reduction process from an initial cohort of 115 Mathematics Education students, data from 108 students were identified as relevant and met the purposive sampling criteria for further analysis. This cognitive mapping was executed using the Van Hiele Geometry Test (VHGT) instrument, structured with a total of 25 items. Each level of the Van Hiele thinking hierarchy in the test was represented by five specific items. According to Siregar (2025), this evaluation strictly adheres to the core principles of Van Hiele Theory, which mandate sequential and structured cognitive development, wherein subjects must master the lower levels before the attainment of a higher level can be academically validated.

Table 1. Percentage of Van Hiele Geometric Thinking Level Attainment

Level	Number of Students	Percentage
0 (Visualization)	24	22,22%
1 (Analysis)	25	23,15%
2 (Informal Deduction)	14	12,96%
3 (Formal Deduction)	3	2,78%
4 (Rigor)	2	1,85%
No Fit	35	32,41%
Did Not Meet	5	4,63%
Total	108	100%

The distribution of Van Hiele geometric thinking levels among the 108 students revealed that 5 students (4.63%) did not meet the minimum passing criteria at the basic thinking level. For subjects following an intact sequential trajectory, 24 students (22.22%) were categorized at Level 0 (Visualization), whereas the most dominant population within the hierarchical path fell under Level 1 (Analysis) with 25 students (23.15%). Progressing to more abstract stages, 14 students (12.96%) achieved Level 2 (Informal Deduction), 3 students (2.78%) reached Level 3 (Formal Deduction), and only 2 students (1.85%)

attained Level 4 (Rigor). Beyond this linear distribution, this study also recorded an anomalous finding of 35 students (32.41%) classified into the No Fit category. This difficulty in maintaining consistency across sequential level prerequisites aligns with the findings of Mahfudy & Afriana (2024), in which the inability to grasp basic concepts and information often directly results in students' failure to develop sequential problem-solving steps.

The presence of 5 students in the initial prerequisite group, as well as 24 students at Level 0 (Visualization), underscores that some pre-service teachers remain at a highly fundamental phase of spatial recognition. As observed by Ruslau et al. (2025), at this level, the subjects' cognitive framework in interpreting geometric entities is still dominated by holistic visual perception and relies purely on the outward appearance of the figures, with limited ability to analyze constituent properties. This quantitative evidence directly confirms the initial thesis that a cognitive misalignment exists in the classroom, rendering students vulnerable to conceptual disorientation when confronted with high abstraction demands.

The cognitive transition toward Level 1 (Analysis), encompassing 25 students (23.15%), signifies the emergence of descriptive observation capacities within a segment of the population. In line with the research findings of Hikmayani et al. (2023), the analysis stage enables subjects to recognize the properties of geometric figures based on measurements and angles; however, their mindset often still perceives these shapes as independent, isolated entities, meaning they may have difficulty recognizing hierarchical relationships among geometric figures. This limited understanding of the relationships between figures is precisely what causes students to struggle when integrating concepts to solve problems that require the synthesis of multiple properties.

A total of 14 students (12.96%) who have reached Level 2 (Informal Deduction) demonstrate positive initial readiness toward the structural-connective thinking stage. As outlined by Simasiku & Rabaza (2026), at this phase, subjects begin to reason in a structured manner regarding the interrelationships among mathematical properties and gradually recognize the validity of simple deductive arguments. Although this represents positive development, the significant decline in the number of subjects indicates that the informal deduction stage remains a highly challenging epistemological bridge requiring institutional attention.

Entering the higher-order thinking spectrum at Level 3 (Formal Deduction), the decline in the number of subjects to merely 3 individuals (2.78%) reflects the magnitude of

the actual academic challenges. This aligns with the observation by Palayukan et al. (2023) who assert that the deduction stage represents a relatively high and highly challenging cognitive level, because subjects no longer merely accept proofs passively but are required to possess the capability to understand logical relationships, axioms, definitions, and theorems, as well as construct formal proofs within an axiomatic system. Students' systemic difficulties in navigating these proof procedures are fundamentally rooted in the fragile internalization process of their basic logical reasoning.

The peak of cognitive challenge was recorded at the attainment of Level 4 (Rigor), where only 2 students (1.85%) were able to reach the highest limit of mathematical precision. The rigor level demands the capacity to comprehensively manipulate pure information within alternative non-Euclidean geometric systems. Mapping at this highest point reinforces the argument by Okeke et al. (2024) that mastering advanced geometric system manipulation requires a solid conceptual foundation and robust logical argumentation, rather than merely resulting from rote learning. This achievement strongly requires a foundation of consistent analytical refinement exercises.

Beyond the conventional hierarchical trajectory, the high proportion of students in the No Fit category (32.41%) emerges as a significant finding. Rather than indicating a specific level of mastery, this category highlights inconsistent patterns in students' geometric reasoning development. Students in this group succeeded in answering advanced items while failing the basic prerequisites. According to Aries et al. (2024) differences in cognitive styles can influence how information is processed. In this context, the No Fit anomaly serves as a possible explanation for structural vulnerabilities in students' understanding. Without a solid conceptual foundation, students may struggle to connect basic properties with higher-order logical deductions, leading to inconsistent performance when faced with complex geometric problems.

Systematically, the descriptive overview of this cohort's evaluation indicates that diagnosing thinking levels is a crucial step for mathematics education programs. The finding that the majority of pre-service teachers are still at Level 0 and Level 1 raises significant concerns for their future professional practice. If pre-service teachers have not mastered relational and deductive reasoning, they may face difficulties in effectively teaching complex geometric concepts to their future students, potentially perpetuating fundamental misconceptions. Therefore, to overcome these structural challenges, future intervention research is recommended to design and test interactive cognitive scaffolding strategies. Such interventions should be aligned with the students' current cognitive stages,

ensuring that the spatial and deductive competencies of these future educators can develop in a solid, meaningful, and hierarchical manner.

CONCLUSION

Based on the mapping analysis using the Van Hiele Theory framework, this study concludes that the geometric thinking levels of prospective mathematics teachers are still predominantly concentrated at the foundational tiers. Specifically, the empirical data reveals a critical cognitive stagnation, with the majority of students occupying Level 0 (Visualization: 22.22%) and Level 1 (Analysis: 23.15%), while only a minute fraction reached the advanced stage of Level 4 (Rigor: 1.85%). Most notably, the study uncovers a highly significant anomaly within the cohort, where 32.41% of the students fall into the "No Fit" category. This high percentage of cognitive inconsistency indicates that many prospective teachers exhibit mastery that is not sequential, as they likely rely on mechanical rote learning to solve advanced abstract problems while fundamentally failing to grasp the underlying visual and analytical prerequisites. Consequently, it is evident that the majority of students still depend on holistic visual perception and have yet to solidly master the relational and deductive logical architecture required for advanced geometry.

The pedagogical implications of these findings are profound. There is a critical and widening gap between the complex cognitive demands of higher education geometry coursework and the students' actual reasoning structures. If left unaddressed, this cognitive deficit will severely hinder their future pedagogical effectiveness because future educators cannot authentically teach reasoning levels they have not mastered themselves. To mitigate this issue, higher education instructional designs must urgently shift away from immediate and advanced deductive approaches. Instead, lecturers are strongly recommended to implement systematic cognitive scaffolding strategies, such as utilizing interactive geometric software to visually bridge the transition from informal deduction to formal axiomatic proofs. Furthermore, since this study is limited to a descriptive quantitative mapping of cognitive levels, future research is highly recommended to design, test, and evaluate targeted instructional interventions. Such empirical interventions are essential to repair these cognitive anomalies and rebuild the students' spatial and deductive competencies in a strictly hierarchical and meaningful manner.

DECLARATIONS

Author Contribution : Author 1: Conceptualization, Methodology, Validation,

Supervision.

Author 2: Investigation, Resources, Writing - Original Draft, Project administration, Funding acquisition.

Author 3: Formal analysis, Visualization.

Author 4: Writing - Review & Editing.

Funding Statement : The authors gratefully acknowledge the financial support for this research provided by the Institute for Research and Community Service (LP2M) of UIN Sunan Gunung Djati Bandung through the Output-Based Cost Standard Research Funding Scheme (Skema Bantuan Pembiayaan Penelitian Berbasis Standar Biaya Keluaran) for the 2026 Fiscal Year.

Conflict of Interest : This research received funding from the Output-Based Cost Standard Research Funding Scheme at the PTKI Working Unit of UIN Sunan Gunung Djati Bandung for the 2026 Fiscal Year under Contract Number B-162.32/Un.05/V.2/TL/04/2026.

REFERENCES

Aries, N. S., Monoarfa, F., Ismail, R. P. (2024). Teori Belajar Van Hiele dalam Penyajian Materi Geometri Terhadap Kemampuan Berpikir Matematis Siswa Sekolah Dasar Ditinjau dari Gaya Kognitif. (2024). Cokroaminoto Journal of Primary Education, 7(2), 782-794. https://doi.org/10.30605/cjpe.7.2.2024.4841

Fitri, Y., & Refnywidialistuti. (2025). Analisis Kesulitan Mahasiswa dalam Mempelajari Geometri: Studi Kasus pada Penempatan Titik Koordinat Tiga Dimensi. Jurnal Ilmiah Pendidikan Scholastic, 9(2), 73–79. 10.36057/jips.v9i2.730

Hikmayani, J., Tahir, M., & Rosyidah, A. N. K. . (2023). Analisis Kemampuan Pemahaman Konsep Geometri Siswa Kelas IV Menurut Teori Van Hiele di SDN 06 Cakranegara. Jurnal Ilmiah Profesi Pendidikan, 8(1), 133–141. https://doi.org/10.29303/jipp.v8i1.1111

Khomeni, A., Junaedi, Y., & Hilmi, Y. (2025). Analisis Kemampuan Spasial Mahasiswa Dalam Memahami Konsep Geometri Dasar. Wilangan: Jurnal Inovasi Dan Riset Pendidikan Matematika, 6(1), 92–98. 10.62870/wjirpm.v6i1.32196

Mahfudy, S., & Afriana, H. (2024). Identifikasi kesulitan siswa dalam memecahkan masalah geometri berdasarkan tingkatan berfikir Van Hiele. Journal of Math Tadris, 4(2), 97–114. 10.55099/jmt.v4i2.163

Maryono, I., & Sobarningsih, N. (2024). Pengembangan Media Tutorial Praktikum Geometri Berbasis Geogebra untuk Meningkatkan Kemampuan Pemahaman Konstruksi Geometri Mahasiswa. Jurnal Analisa, 10(2), 150–165. https://doi.org/10.15575/ja.v10i2.44174

Nabila, D. R., Mailani, E., Ketaren, M. A., Nababan, F. A., Nababan, J. F., & Muhammad, F. (2025). Meningkatkan Pemahaman Geometri Melalui Aktivitas Praktis Di Sekolah Dasar. Primary Education Journals (Jurnal Ke-SD-An), 5(3), 1048–1053. https://doi.org/10.36636/primed.v5i3.5907

Ndungo, I., Balimuttajjo, S., Akugizibwe, E., & Muwonge, C. M. (2026). Comparing technology-enhanced and conventional Van Hiele Phased Instruction in advancing learners through Van Hiele levels in transformation geometry. Cogent Education, 13(1). https://doi.org/10.1080/2331186X.2026.2716983

Okeke, A. M., Egara, F., & Mosia, M. (2024). The Van Hiele Model's Effects on Student Attitudes and Achievement in Geometry Content of Senior Secondary Mathematics. The International Journal of Pedagogy and Curriculum, 32(1), 81–105. https://doi.org/10.18848/2327-7963/cgp/v32i01/81-105

Palayukan, H., Langi, E. L., Palengka, I., & Hima, L. R. (2023). Analisis Kemampuan Berpikir Siswa Berdasarkan Teori Van Hiele pada Materi Kubus dan Balok. EDUKASIA: Jurnal Pendidikan Dan Pembelajaran, 4, 879–884. https://doi.org/10.62775/edukasia.v4i2.366

Palobo, M., Tembang, Y., & Dadi, O. (2026). From Recognition to Logical Deduction: Assessing the van Hiele Levels of Geometric Thinking Among Students of Diverse Disciplines. 8(1), 210–229. https://doi.org/https://doi.org/10.38114/riemann.v8i1.145

Panglipur, I. R. (2022). Identifikasi Level Berpikir Geometri Mahasiswa Menurut Teori Van Hiele pada Materi Geometri Analitik. MATH-EDU: Jurnal Ilmu Pendidikan Matematika, 7(2), 113–121. https://doi.org/10.32938/jipm.7.2.2022.113-121

Purwaningrum, J. P., & Purwoko, R. Y. (2024). Miskonsepsi Matematis Materi Geometri pada Mahasiswa Calon Guru Matematika. Euclid, 10(4), 663–679. https://jurnal.ugj.ac.id/index.php/Euclid/article/view/9217/4040

Ramadan, A., Naufal, M. A., Ashari, N. W., & Hassan, M. N. (2026). Improving Students' Geometric Thinking Levels through a Van Hiele Learning Module Integrated with Ethnomathematics. Venn: Journal of Sustainable Innovation on Education, Mathematics and Natural Sciences, 5(5), 1052–1061. https://doi.org/https://doi.org/10.53696/venn.v5i5.607

Renanda, A., Qohar, Abd., & Chandra, T. D. (2023). Analisis Peningkatan Level Berpikir Geometri Mahasiswa Berdasarkan Teori Van Hiele dengan Pendekatan Konstruktivisme. Jurnal Tadris Matematika, 6(1), 101–114. https://doi.org/10.21274/jtm.2023.6.1.101-114

Ruslau, M. F. V., Oswaldus Dadi, & Nurlianti. (2025). The impact of GeoGebra AR on students' geometric thinking based on Van Hiele theory. Journal of Honai Math, 8(1), 115–128. https://doi.org/10.30862/jhm.v8i1.871

Safitri, R., Nurfadhilah, S., Suhandi, T. A., & Mulyeni, S. (2026). Adaptasi Mahasiswa Baru dengan Beban Akademik. Jurnal Nakula: Pusat Ilmu Pendidikan, Bahasa Dan Ilmu Sosial, 4(2), 72–82. https://doi.org/10.61132/nakula.v4i2.2694

Samudra, D. A., Mahfudy, S., & Negara, H. R. P. (2025). Kemampuan Berpikir Kritis Mahasiswa Calon Guru Matematika dalam Menyelesaikan Masalah Geometri ditinjau dari Gaya Kognitif. Kognitif: Jurnal Riset HOTS Pendidikan Matematika, 5(2), 522–533. https://doi.org/10.51574/kognitif.v5i2.3260

Silmi, U., & Muiz L., D. A. (2022). Systematic Literature Review: Teori Van Hiele dalam Meningkatkan Kemampuan Berpikir Geometris Siswa Sekolah Dasar. PEDADIDAKTIKA: Jurnal Ilmiah Pendidikan Guru Sekolah Dasar, *9*(2). https://doi.org/10.17509/pedadidaktika.v9i2.53166

Simasiku, F. S., & Rabaza, M. (2026). Enhancing grade 9 teachers' geometric thinking through Van Hiele theory-based geoboard workshops: A reflective study. Eurasia Journal of Mathematics, Science and Technology Education, 22(2). https://doi.org/10.29333/ejmste/17796

Siregar, N. A. R., & Elvi, M. (2024). Kemampuan Berpikir Geometri Mahasiswa Calon Guru Berdasarkan Teori Van Hiele. Journal Numeracy, 11(1). https://doi.org/10.46244/numeracy.v11i1.2623

Siregar, T. (2025). Developing a GeoGebra-Based Mathematics Learning Media Using the Van Hiele Theory Approach to Enhance Students' Understanding of Maximum and Minimum Value. https://doi.org/10.20944/preprints202511.0033.v1

Usiskin, Z. (1982). Van Hiele Levels and Achievement in Secondary School Geometry. CDASSG Project. Evanston, IL: Northwestern University.

Van Hiele, P. M. (1986). Structure and Insight: A Theory of Mathematics Education. Academic Press.

Wicaksono, A. B., & Juniati, D. (2022). Level Berpikir Geometris Mahasiswa Calon Guru Matematika Berdasarkan Teori Van Hiele. AKSIOMA: Jurnal Program Studi Pendidikan Matematika, 11(3), 2479–2487. https://doi.org/10.24127/ajpm.v11i3.5491