Pasundan Journal of Mathematics Education: Jurnal Pendidikan Matematika
Vol. 12 No. 1, Mei 2022, hal. 44-59
DOI: 10.23969/pjme.v12i1.5280
https://journal.unpas.ac.id/index.php/pjme

Critical Thinking Process Analysis Based on Van Hiele's Theory Through the Discovery Learning Model

Eti Sofiyati
SMP Negeri 9 Banjar
*sofiyatieti@gmail.com

Abstrak

Tujuan penelitian ini adalah untuk menganalisis proses berpikir kritis peserta didik berdasarkan teori van Hiele yang melalui model *discovery learning* dan pembelajaran konvensional. Metode yang digunakan pada penelitian ini adalah studi kasus deskriptif kualitatif. Sampel penelitian diambil secara *purposive sampling* dengan mengambil 4 subjek dari kelas 7D dan 3 subjek dari kelas 7C. Instrumen yang digunakan untuk mengumpulkan data berupa instrumen *Van Hiele Geometri Test* (VHGT), soal tes berpikir kritis, dan wawancara. Analisis kualitataif dilakukan dengan reduksi data, penyajian data dan verifikasi. Hasil penelitian menunjukkan bahwa analisis proses berpikir kritis peserta didik berdasarkan teori van Hiele yang melaui model *discovery learning* dalam menyelesaikan soal segiempat meliputi peserta didik dengan tingkat berpikir geometri pre 0, level 0, level 1 dan level 2 dengan ketercapaian proses berpikir kritis sebesar 42% sedangkan untuk pembelajaran konvensional meliputi peserta didik dengan tingkat berpikir geometri pre 0, level 0 dan level 1 dengan ketercapaian proses berpikir kritis sebesar 28%.
Kata kunci: Discovery Learning, Proses Berpikir Kritis, Teori van Hiele

Abstract

This research aimed to analyze students' critical thinking processes based on van Hiele's theory through discovery learning and conventional learning models. The method used in this research is a sequential explanatory mix method. Quantitative research sample were taken by random sampling in two class, class 7D with 21 students as the experimental class and class 7C with 22 students as the control class. The qualitative research samples were taken by purposive sampling by taking 4 subjects from class 7D and 3 subjects from class 7C. The data collection instruments are the Van Hiele Geometry Test instrument, critical thinking test, and interview. Qualitative analysis was used for data reduction, data provision, and verification. The result showed that analysis of student's critical thinking processes based on van Hiele's theory through the discovery learning model to solve quadrilateral problems included students with geometric thinking levels pre 0, level 0, level 1, and level 2 with the achievement of critical thinking processes by 42% and included in the sufficient category, for conventional learning included students with geometric thinking levels pre 0, level 0, level 1 and level 2 with the achievement of critical thinking processes by 28% and included in the low category.
Keywords: *Critical Thinking Processes, Geometry, Quadrilateral, Van Hiele's Theory.*

Introduction

Critical thinking is a process that aims to enable us to make reasonable decisions to minimize mistakes in doing various things. Critical thinking in mathematics is the ability and disposition to engage prior knowledge and mathematical reasoning and use cognitive strategies to reflectively generalize, prove, or evaluate unfamiliar mathematical situations (Sulistiani & Masrukan, 2016). Much information is available and can be obtained easily by students. However, not all of this information is valid information. A strategy is needed that can filter information with reasoning and critical abilities to be able to sort and generalize the information correctly.

Therefore, students need to have critical thinking skills. Abdullah (2013), stated that "Concerning learning mathematics in students at school, students' critical thinking skills must identify, connect, evaluate, analyze, and solve various mathematical problems their applications." Then according to Marfuah et al., (2016) that students can solve problems effectively by thinking critically. Having knowledge or information alone is not effective enough, but students must be able to solve problems with their ability to sort out information, methods and determine the most effective decisions through critical thinking.

However, the importance of mathematics is not accompanied by a good perception of students towards mathematics, which is based on Nasution (2018) stated that "Mathematics for students is generally a subject that is not liked, is considered a difficult, complicated and deceptive science." This can be seen from student tests whose average class is still below the minimum completeness criteria. The following is the data on the average daily test scores for students of class VII SMP Negeri 9 Banjar for the 2020/2021 academic year.

Table 1. Average Value of Mathematics Daily Test For Class VII Students SMP Negeri 9 Banjar For The 2020/2021 Academic Year

Material	Average	Minimum Completeness Criteria
Lines and Angles	45,30	65
Quadrilateral and triangle	41,29	65
Data Presentation	55,70	65

Based on the table, it can be seen that the student's abilities in mathematics are still not maximal. At the same time, mathematics can train students' critical thinking skills. Then, in reality, critical thinking in learning mathematics is still not optimal. This is based on Amir

(2015) that "In the implementation of education, especially in learning mathematics in elementary schools, critical thinking competencies are rarely considered by teachers in learning." The following is one form of answer students give when working on questions. One of these answers represents most of the ways to solve problems when students are given a problem.


Latihan
1. Perbandingan uang Nita dan Ani adalah 4:5. Jika jumlah uang mereka adalah Rp. 270.000,00 berapa uang mereka masing-masing.
Jawab:
Perbandingan uang nita dan Ani
$\frac{4}{4+5} \times 270.000,00$
$= \frac{4}{9} \times 270.000,00$
$= 120.000$ (uang Nita)
$\frac{5}{4+5} \times 270.000$
$= \frac{5}{9} \times 270.000$
$= 150.000$ (uang Ani)

Figure 1. Students' Answer

Based on the figure 1, it can be seen that students are less able to solve problems using critical thinking processes. Though critical thinking skills are not a skill that can be developed by themselves, these skills must be trained through the provision of stimuli that will lead a person to be able to think critically (Wahyuni, 2016). In this case, schools as education providers have a responsibility to help students in the classroom, especially in learning mathematics, develop critical thinking skills (Wahyuni, 2016). Therefore, researcher is interested in studying the critical thinking process of students, especially in geometry material that focuses on quadrilateral material. Because based on Muslim (2017) stated "Geometry is a material that has many problems in learning mathematics, but geometry is also important to learn because problem-solving from learning geometry will train critical thinking skills". The critical thinking process of students in rectangular material will be analyzed based on van Hiele's theory which states that there are five levels of thinking of students in learning geometry.

According to Hiele (Pratama et al., 2018),"Each level indicates a person's thinking ability in learning geometry. It is important to distinguish the five levels of thought in geometry. It is also very important to understand what and how a person's thinking level is".

That need for teacher start the learning process and will become consideration to make teaching materials in order to adapt to the abilities of students. Then, “previous researches done showed that the application of van Hiele theory ini geometry lesson brought about positive implication” (Abidin & Abu, 2021). Therefore, van Hiele theory will be used to make better learning outcomes.

In addition, to support the development of critical thinking processes, a learning model is needed that can improve critical thinking skills. One of them is the discovery learning model. According to Nugrahaeni et al., (2017),"The discovery learning model provides opportunities for students to think, discover, argue, and cooperate through scientific learning activities so that they can train and improve critical thinking skills". Discovery learning puts forward the active role of students. According to Fiquroisyin (2020), “Discovery learning is a way of teaching that involves students in mental activities through exchanging opinions, discussions, seminars, reading alone, and trying on their own so that children can learn on their own. Therefore, the activity of students carried out is reasoning”. This supports students in learning geometry material. Research conducted by In’am & Hajar (2017) shows that in learning geometry, discovery learning models are very effective. The excellent student geometry learning outcomes evidence this after being subjected to the discovery learning model.

Discovery learning is expected to develop geometry skills through students who actively find their concepts in learning. Then the teacher only provides sufficient direction. Through the active role of students, it is hoped that it will also be an opportunity to think more deeply and critically and, of course, make learning more meaningful. Then, as mentioned earlier, to achieve the objectives of learning mathematics in the classroom, students' abilities in critical thinking processes are required, which are facilitated by a supportive learning model. Therefore, Farib et al., (2019) stated, "Given the importance of critical thinking in the mathematics learning process, the thinking process can theoretically be facilitated through the discovery learning model." Through a learning model that can stimulate students in their critical thinking process, it is hoped that it will positively impact learning mathematics. Based on this explanation, this study aims to analyze students' critical thinking processes based on van Hiele's theory through the discovery learning model in

solving quadrilateral problems and analyze students' critical thinking processes based on van Hiele's theory through direct learning models in solving quadrilateral problems.

Method

The research method used is the sequential explanatory mix method. This mixed-method in the first stage uses quantitative methods, and in the second stage uses qualitative methods. Analysis of students' critical thinking processes using qualitative research methods. The type of research used in this qualitative research is a case study. Qualitative descriptive case study research aims to describe students' critical thinking processes based on van Hiele's theory through discovery learning models and conventional learning in solving problems on rectangular material.

Population, Sample and Research Subject

In this study, the population was all seventh-grade students at SMPN 9 Banjar, while the samples were taken from two grade VII students at SMPN 9 Banjar. The experimental class sample got a discovery learning model. Then the control class got a conventional learning model. Then for the second stage of the test and the interview sample, the research subjects were selected by purposive sampling. The selection of subjects for this interview considers students based on VHGT grouping, namely those at levels 0 to 3. The research subjects were taken seven students from two classes with each criterion from level 0 to level 2.

Resesearch Instrument

This first test determines the students' thinking ability in quadrilateral geometry. This test is called the van Hiele Geometry Test (VHGT). Usiskin (1982) developed the test in The Cognitive Development and Achievement in Secondary School Geometry Project (CDASSG) project. The test consists of multiple-choice with a total of 25 questions. Of the 25 questions, there are five levels of van Hiele's geometric thinking. The text used English and was translated in this study into Indonesian. In the second test is a tool in the form of a test in the form of a description, which is based on indicators of achievement of quadrilateral material competence and fulfills the critical thinking process. Interviews were conducted after taking the subject based on the results of the stage 1 test. In the implementation, as a reference, the researchers used interview guidelines. The questions are arranged to interpret the ability of

students to carry out critical thinking processes, which include clarification, assessment, inference and strategy.

Data Analysis Technique

Miles and Huberman (Sugiyono, 2016) reveal that activities in qualitative data analysis include data reduction, data presentation and data conclusion/verification. This qualitative data analysis is known as the Miles and Huberman Model. We are conducting interviews with selected subjects using a recording device in the form of a mobile phone. I am transcribing the results of the interview. The following is the coding performed on the results of the interviews.

P : Researcher	Pn : Question n
PE/PK : Students	PE/K-n: Students' answers to the nth question

I am doing a re-examination so that there are no errors in the results of the interview transcripts.

Results and Discussion

The Van Hiele Geometry Test (VHGT) was conducted after the learning process in class 7C with 22 students and 7D with 21 students. The purpose of this first test is to obtain data on the geometric thinking level of students by classifying students into geometric thinking levels according to van Hiele's theory. Then one subject is taken at each level of geometric thinking based on the test results. The VHGT test results data for the experimental class and the control class are summarized as shown in the following table.

Table 2. Summary of Experimental Class and Control Class VHGT Test Results

Geometric Thinking Level	Number of Students		Percentage	
	Experimental Class	Control Class	Experimental Class	Control Class
Level Pre 0	1	1	4,76%	4,55%
Level 0 (Visualization)	4	9	19,05%	40,91%
Level 1 (Analysis)	15	12	71,43%	54,54%
Level 2 (Deduction)	1	0	4,76%	0%
Total	21	22	100%	100%

Based on the VHGT test results table, it can be described that for the geometric thinking level 0 (visualization), there are 4 students from the experimental class, namely 19.05% of the number of students in the experimental class. There are 9 students from the control class, namely 40.91% of the number of students in the control class. In comparison,

for the geometric thinking level 1 (analysis), there were 15 students from the experimental class, 71.43% of the number of students from the experimental class. There were 12 students from the control class, 54.54% of the total control class. Then, for geometry level 2 (deduction), it was found that 1 student from the experimental class or 4.76% of the number of students from the experimental class. From the results of the VHGT test, each student, or 4.76% of the total experimental class students and 4.55% of the control class students, could not even reach level 0 (visualization). So by the researchers, this group was included in the Pre 0 group. So, the geometric thinking level of the students of SMP Negeri 9 Banjar was between the pre 0 level to level 2. After grouping the thinking levels of students based on van Hiele's theory, then subjects are taken from each level of thinking with consideration of communicative criteria and mastery of the material as well as considerations from the mathematics teacher, subjects selected from the experimental class to be analyzed are listed in table 3 below.

Table 3. Selected Research Subjects from the Experimental Class

Geometric Thinking Level	Selected Subject
Pre 0	PE-13
0 (Visualization)	PE-7
1 (Analysis)	PE-1
2 (Deduction)	PE-3

Table 3 shows the subjects taken, namely 4 students from the experimental class, including 1 student from pre 0 level, namely PE-13, 1 student from level 0, namely PE-7, 1 student from level 1, namely PE-1, and 1 student. level 2 students, namely PE-3.

The grouping of students' thinking levels based on van Hiele's theory was also carried out in the control class. Subjects were also taken from each level of thinking by considering the communicative criteria and mastery of the material, as well as considerations from the mathematics teacher, the selected subjects from the control class to be analyzed are listed in table 4 below.

Table 4. Selected Research Subjects from the Control Class

Geometric Thinking Level	Selected Subject
Pre 0	PK-20
0 (Visualization)	PK-2
1 (Analysis)	PK-5

Table 4 shows the subjects taken, namely 3 students from the control class, including 1 student at pre 0 levels, namely PK-20, 1 student at level 0, namely PK-2, and 1 student at level 1, namely PK-5. After the subjects were selected, a critical thinking test was conducted on the 7 samples. Then interviews were conducted to obtain more accurate and in-depth information. The researcher then analyzed the data obtained from the tests and interviews.

Based on the results of data analysis regarding students' critical thinking processes in solving problems on rectangular material. Information was obtained that students whose learning process used the discovery learning model with code PE-13, namely subjects from the pre 0 level, based on van Hiele's theory, could go through the clarification stage with 66.67%. For the strategy and tactics stage, the inference and assessment of the subject have not been able to pass it for all numbers. In other words, the achievement is 0%. Meanwhile, students whose learning process uses conventional learning models with PK-10 code, namely subjects from the pre 0 level based on van Hiele's theory, can go through the clarification stage on questions number 1, 2, and 3 with 50% achievement. For the strategy and tactics stage, the inference and assessment of the subject have not been able to pass it for all numbers in other words, the achievement is 0%.

Students at the pre 0 level belong to students with low cognitive levels and are not even able to recognize the visualization of various rectangular shapes correctly. In Jabar & Noor (2015), stated that at this stage or the pre-introduction/visualization stage, students only provide some of the characteristics of the visual form, which results in the inability to distinguish between triangles and quadrilaterals, unable to distinguish between rhombuses and parallelograms. As happened to the following PK-20 subject.

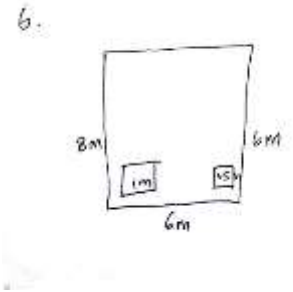

Figure 2. Answers to PK-20 Subjects Question Number 6

PK-20 subject who redraws a right-angled trapezoid on a critical thinking test question with a rectangular shape. Then, they could only go through the clarification stage on

questions that were still at the easy and medium level. This is in line with the research results from Gayatri et al., (2013), namely that students with low levels of ability do not have reasoning and the ability to solve real problems. In addition to being unable to go through the strategy and tactics stages and subject inference at the pre 0 levels, they are also unable to go through the assessment stage. This is in line with the results of research from Rizqiani & Hayuhantika (2019) that students with low abilities are unable to ensure the correctness of their answers because they do not perform test solution.

Students whose learning process uses the discovery learning model with code PE-7 originating from level 0 of van Hiele's thinking level can go through the clarification stage at numbers 1, 2, 3, 4, and 5, or the achievement at the clarification stage is 83.33%. Subjects also only went through the stages of strategy and tactics and inference in questions number 1 and 4 with achievement of 33.33%. Meanwhile, for the assessment stage, the subject has not been able to go through all numbers because he has only mastered a single solution to several questions. In other words, the achievement for this stage is 0%. Furthermore, students whose learning process uses conventional learning with the PK-2 code originating from level 0 of van Hiele's thinking level can go through the clarification stage at numbers 1, 2, 4, and 5 or the clarification stage's achievement of 66.67%. The subject also only went through strategy, tactics, and inference stages in questions number 1 and 2. Namely, the achievement of this stage was 33.33%. Meanwhile, for the assessment stage, the subject has not been able to pass for all numbers because he only has mastered a single solution to several questions in other words, the achievement is 0%.

For students who are at level 0 (visualization), they recognize geometric shapes only for their visual characteristics and appearance. As seen in the critical thinking process test, the level 0 subject can recognize what flat shapes are meant in the question. However, in some questions, students could not identify the properties of a flat shape, as happened in the PE-7 subject, where they misrecognized the properties of a rhombus. This is in line with Fuys (1988) that at level 0, students already know the basic concepts of geometry-based solely on visual characteristics or appearance of shapes but do not yet understand their properties. Then Amir (2015) stated, "At this level students have not been able to answer questions about the properties of a square, that a square has all sides the same length, both diagonals are the same length, and each other is perpendicular and so on."

Furthermore, students whose learning process uses the discovery learning model with code PE-1 originating from level 1 subject can go through all stages in question number 1, and go through the stages of strategy and tactics as well as inference in numbers 1, 2, and 4 or with stage achievement. This is 50%. For the rest, the subject can only go through the clarification stage. Then the students whose learning process uses conventional learning with PK-5 code originating from level 1 subject go through the clarification stage at numbers 1, 2,3, 4, and 5 or with the achievement of the clarification stage of 66.67% through the strategy and strategy stages. Tactics and inferences in numbers 1, 2, and 4 are with 50% achievement. However, for the assessment stage, the achievement is 0%. At level 1 (analysis) students, they have begun to recognize the properties of the observed geometric shapes. For example, as Mulyadi & Muhtadi (2019) stated, "At this level, students can say that a shape is a rectangle because it has 4 sides and all angles are right angles". This can be seen in the PE-1 subject, who was able to identify the nature of the flat shape of a rhombus at the time of the critical thinking test. However, at level 1, students cannot understand the relationship between geometric shapes. Seen in the critical thinking process at the assessment stage, they cannot show the relationship between the area of a triangle and a quadrilateral. This is in line with Clements (1992), which states that at this stage, students have not been able to understand the relationship between geometric shapes and understand the definition of geometry.

Then students whose learning process uses the discovery learning model with PE-3 code originating from level 2 subjects can go through all stages of question number 1 and go through the stages of strategy and tactics as well as inference in numbers 1, 2, 3, and 4 or with achievement at this stage, it is 66.67%. At the assessment stage, the achievement is 16.67%. For the rest, the subject can go through the clarification stage. Students at level 2 already know and understand the properties of geometric shapes that are interconnected with each other. Seen in the PE-3 subject at the following assessment stages.

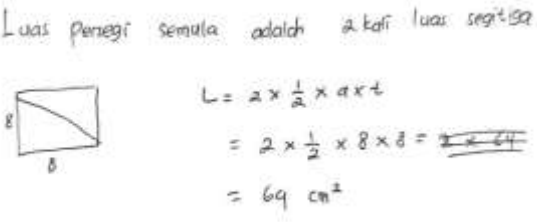

Figure 3. Answers of PE-3 Subjects Question Number 1

Figure 3 shows an answer about how the subject gives another way of solving a problem by connecting the area of a quadrilateral and a triangle. The following are the results of interviews with these subjects.

P_{10}	:	Is there another way to solve this problem?
$PE\text{-}3_{10}$	:	You can use the formula for the area of a triangle to find the area of a quadrilateral.
P_{11}	:	Try to explain the other way!
$PE\text{-}3_{11}$	:	Divide the quadrilateral by 2, then use the area of the triangle, the base is 8 and the height is 8 times 2. You get the original square area.
P_{12}	:	Is this method the same conclusion as the previous method?
$PE\text{-}3_{12}$	:	Same, the original area of the square is 64 cm^2

Based on the results of the written test and interview on solving the problem, PE-3, during the critical thinking process at the assessment stage, was able to relate the properties of triangles and quadrilaterals. This is supported by Pratama et al., (2018), namely, the higher the level of students' geometric thinking, the better their geometry skills are compared to students who were at the previous level. In line with the statement from Ahdhianto (2016), at the level of sequencing or deduction, students already have the ability to know the related relationship between a geometric shape and other geometric shapes..

Students at level 2 have the greatest achievement in critical thinking processes compared to students at the previous level. It can be said that students at this level have high abilities because they are able to complete critical thinking test questions quite well. This is in line with the results of Rizqiani & Hayuhantika (2019), "high-ability students carry out the completion strategy correctly and tend to re-assure the truth so that the mistakes they make can be known and corrected.".

The analysis of students' critical thinking processes based on the van Hiele geometry level shows the results that the higher students are in the van Hiele geometry level, the better results in solving rectangular material problems with a critical thinking process. This is, of course, supported by geometry material, including quadrilateral material providing many basic skills by helping students to solve problems, as stated by Karapınar & Alp İlhan (2018) geometry helps students to connect geometric structures with other mathematical sub materials. They encounter in their environment and solve problems. Problems they face in their daily lives through the relationships they build. In solving this problem, a focused thought is needed to find a solution to the problem, namely, with a good ability to carry out the critical thinking process. In accordance with Halpern (2014) defines critical thinking as a type of thinking that involves solving problems, formulating assumptions, considering possibilities, and making decisions.

The learning model also supports the ability of students to solve rectangular problems. This can be seen in the achievement of students on the critical thinking test where the learning using the discovery learning model averages the achievement of the critical thinking process stages of 42%, while the achievement of students on the critical thinking test using conventional learning the average achievement of the critical thinking process stages is 28%. Based on Tirtaprimasyah & Susanto (2015) stated, that there are several learning models that have a relationship that is in accordance with van Hiele's geometry learning, including Discovery learning. Then Darwis et al., (2018) states that the discovery learning model is oriented toward maximum student involvement, developing a critical and confident attitude of students about what is found in the discovery process. So it can be said that the discovery learning model is one of the learning models that can train students' thinking processes. While the conventional learning model based on Hidayat (2013) states that most students only rely on memorization without understanding the concept of geometry, so they often make mistakes in solving problems.

Conclusion

Analysis of students' critical thinking processes based on van Hiele's theory through discovery learning models in solving quadrilateral problems includes students with geometric thinking levels of pre 0, level 0, level 1, and level 2. Students with geometry level

pre 0 are only able to go through the process. Overall, the critical thinking process based on van Hiele's geometry level, whose learning uses the discovery learning model, has an average critical thinking process achievement of 42% and included in the sufficient category . At the same time, the analysis of students' critical thinking processes based on van Hiele's theory through conventional learning models in solving quadrilateral problems includes students with geometric thinking levels of pre 0, level 0, and level 1. Overall, the critical thinking process is based on the van Hiele geometry level, where the learning process uses conventional learning, the average critical thinking process achievement is 28% and included in the low category.

This research was conducted on rectangular material. In other research opportunities, researchers can conduct research on other geometric materials such as circles, flat and curved side spaces, as well as three-dimensional materials at the high school level. The critical thinking process is one of the student's thinking activities when carrying out the learning process, which of course, will affect the achievement of learning objectives. Therefore, teachers need to try various learning models that can develop students' critical thinking processes. The results showed that the critical thinking process of students was still lacking at the assessment stage. Then for van Hiele's level of thinking, the average student was still at level 0, so it would be better if there was the consolidation of geometry material, especially rectangular material.

Reference

Abdullah, I. H. (2013). Berpikir kritis matematik. *Jurnal Matematika Dan Pendidikan Matematika*, *2*(1), 66–75. https://doi.org/10.18860/jt.v0i0.1442

Abidin, Z. Z., & Abu, M. S. (2021). The improvement of geometric thinking levels of secondary school students using geometry learning video based on van hiele theory. *Modern Perspectives in Language, Literature and Education Vol. 9*, *2*(1), 13–21. https://doi.org/10.9734/bpi/mplle/v9/3633f

Ahdhianto, E. (2016). Pengembangan modul pembelajaran geometri bangun datar berbasis teori van hiele untuk siswa kelas VI Sekolah Dasar. *Pendidikan Dasar Nusantara*, *1*(2), 37–48. https://ojs.unpkediri.ac.id/index.php/pgsd/article/view/219.

Amir, M. F. (2015). Proses berpikir kritis siswa sekolah dasar dalam memecahkan masalah berbentuk soal cerita matematika berdasarkan gaya belajar. *Jurnal Math Educator*

Nusantara, *01*(02), 159–170. http://ojs.unpkediri.ac.id/index.php/matematika/article/download/235/150

Clements, D. H., & Ballista, D. H. (1992). Geometry and spatial reasoning. In D. A.Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 420-464). New York: Macmillan.

Darwis, M., Asdar, & Kurniati. (2018). Efektivitas penerapan model discovery learning dengan pendekatan icare dalam pembelajaran matematika. *Issues in Mathematics Education*, *2*(2), 119–128. http://seminar.uny.ac.id/semnasmatematika/sites/seminar.uny.ac.id.semnasmatematika/files/banner/PM-82.pdf.

Farib, P. M., Ikhsan, M., & Subianto, M. (2019). Proses berpikir kritis matematis siswa sekolah menengah pertama melalui discovery learning. *Jurnal Riset Pendidikan Matematika*, *6*(1), 99–117. https://doi.org/10.21831/jrpm.v6i1.21396

Fiquroisyin, D. (2020). Upaya meningkatkan prestasi belajar siswa kelas V Sekolah Dasar dengan model pembelajaran discovery learning. In *Social, Humanities, and Educational Studies (SHEs): Conference Series, 3*(3), 1–23.

Gayatri, I. G. A. S., Jekti, D. S. D., & Jufri, A. W. (2013). Efektifitas pembelajaran berbasis masalah dan strategi kooperatif terhadap kemampuan menyelesaikan masalah dan hasil belajar kognitif biologi ditinjau dari kemampuan akademik awal siswa kelas x sma negeri 3 mataram. *Jurnal Pijar Mipa*, *8*(2), 41–46. https://doi.org/10.29303/jpm.v8i2.77

Halpern, D. F. (2013). *Though and knowledge*: *an introduction to critical thinking*. Psychology Press.

Hidayat, B. R., *et.al*. (2013). Analisis kesalahan siswa dalam menyelesaikan soal pada materi ruang dimensi tiga ditinjau dari gaya kognitif siswa. *Jurnal Pendidikan Matematika Solusi*, 1 (1). Taken from https://eprints.uns.ac.id/3896/.

In'am, A., & Hajar, S. (2017). Learning geometry through discovery learning using a scientific approach. *International Journal of Instruction*, *10*(1), 55–70. https://doi.org/10.12973/iji.2017.1014a

Indrawan, R., & Yaniawati, P. (2014). *Metodologi penelitian kuantitatif, kualitatif, dan campuran untuk manajemen, pembangunan dan pendidikan*. Bandung: PT Refika Aditama

Jabar, A., & Noor, F. (2015). Identifikasi tingkat berpikir geometri siswa smp berdasarkan teori van hiele. *JPM IAIN Antasari*, *02*(2), 19–28. https://doi.org/dx.doi.org/10.18592/jpm.v2i2.1172

Karapınar, F., & Alp İlhan, O. (2018). An investigation of 8th grade students' knowledge on geometrical objects in terms of van heile levels of understanding geometry. *American Journal of Educational Research*, *6*(2), 96–103. https://doi.org/10.12691/education-6-2-1

Marfuah, I., Mardiyana, & Subanti, S. (2016). Proses berpikir kritis peserta didik dalam dua variabel ditinjau dari gaya belajar kelas IX B SMP Negeri 2 Surakarta tahun pelajaran 2015/2016. *Jurnal Elektronik Pembelajaran Matematiika*, *4*(7), 622–632. https://jurnal.fkip.uns.ac.id/index.php/s2math/article/view/9168/6784

Mulyadi, I., & Muhtadi, D. (2019). Proses berpikir siswa dalam menyelesaikan masalah geometri berdasarkan Teori Van Hiele ditinjau dari gender. *Jurnal Penelitian Pendidikan Dan Pengajaran Matematika*, *5*(1), 1–8. https://doi.org/doi.org/10.37058/jp3m.v5i1.661

Muslim, A. (2017). Proses berpikir kritis siswa pada level deduksi informal van hiele. *Prosiding Seminar Nasional Integrasi Matematika dan Nilai Islami*, *1*(1), 86–94. http://conferences.uin-malang.ac.id/index.php/SIMANIS/article/view/42

Nasution, E. Y. P. (2018). Analisis terhadap disposisi berpikir kreatif siswa pada pembelajaran matematika. *Edumatika : Jurnal Riset Pendidikan Matematika*, *1*(1), 44. https://doi.org/10.32939/ejrpm.v1i1.217

Nugrahaeni, A., Wayan, R. I., & Kartawan, M. A. I. (2017). Penerapan model pembelajaran discovery learning untuk meningkatkan kemampuan berpikir kritis dan hasil belajar kimia. *Jurnal Pendidikan Kimia Indonesia*, *1*(1), 23–29.

Pratama, W., Yusmin, E., & Nursangaji, A. (2018). Kemampuan analisis siswa dalam dimensi tiga dikaji dari tingkatan berpikir van hiele. *Jurnal Untan Pontianak*, *3*, 1–8. https://doi.org/dx.doi.org/10.26418/jppk.v9i1.38957

Rizqiani, S. A., & Hayuhantika, D. (2019). Analisis metakognisi dalam penyelesaian masalah matematika ditinjau dari tingkat kemampuan matematika. *JP2M (Jurnal Pendidikan Dan Pembelajaran Matematika)*, *5*(1), 26–32. https://doi.org/10.29100/jp2m.v5i1.1734

Sugiyono. (2016). *Metode penelitian pendidikan penelitian kuantitatif, kualitatif, dan R & D*. Bandung: Alfabeta

Sukmadinata., & Syaodih, N. (2012). *Metode penelitian pendidikan*. Bandung: Remaja Rosdakarya.

Sulistiani, E., & Masrukan. (2016). Pentingnya berpikir kritis dalam pembelajaran matematika untuk menghadapi tantangan mea. *Seminar Nasional Matematika X Universitas Semarang 2016*, 605–612.

Tirtaprimasyah, H. P. S., & Susanto, N. Y. (2015). Analisis proses berpikir siswa pada pembelajaran geometri kelas x sma berdasarkan teori van hiele berbasis scientific approach. *Seminar Nasional Matematika*, *2*, 567–574. http://seminar.uny.ac.id/semnasmatematika/sites/seminar.uny.ac.id.semnasmatematika/files/banner/PM-82.pdf

Wahyuni, S. (2016). Mengembangkan keterampilan berpikir kritis siswa melalui pembelajaran ipa berbasis problem-based learning. *Program Studi Pendidikan Kimia*

Universitas Terbuka, *23*, 1–10.