ISSN 2715-7458
E-ISSN 2715-7466

Journal of Mathematical Pedagogy
Volume 2, No. 1, Desember 2020, pp. 32-39

Improvement of Students' High Order Thinking Skills (HOTS) Ability through the Application of Van Hiele Theory Assisted by Video Animation

Kairuddin[1], Budi Halomoan Siregar[2], Nur Hasanah Siregar[3]

[1] Universitas Negeri Medan, Medan, Sumatera Utara, 20221, Indonesia
Email: chairuddin2@gmail.com

Abstract

Geometry, which is a branch of mathematics related to visualization often makes students less motivated. Thus, the ability to think mathematically, which is suitable with Van Hiele's geometric thinking ability, need to be promoted in any interactive mathematics learning. Thus, this research is aimed at examining how students' high order thinking skills through the application of Van Hiele's theory with the help of animated videos. Van Hiele's geometric thinking stages consist of visualization, analysis, abstraction, deduction, and rigor. To apply it, researchers used the Thiagarajan learning model known as the Four-D Model. Participants involved in this study were eleventh grade students of an Islamic secondary school in Sumatra, Indonesia. The instruments used were learning tests and student worksheets. Results indicates that Van Hiele's theory aided by video animation helps students improve students' thinking skills and students experience regarding their ability to solve geometric higher-order thinking skill problems.

Keywords: HOTS, Van Hiele, Geometry, Video Animation

Abstrak

Geometri yang merupakan salah satu cabang matematika yang berkaitan dengan visualisasi seringkali membuat siswa kurang termotivasi. Dengan demikian, kemampuan berpikir matematis yang sesuai dengan kemampuan berpikir geometris Van Hiele perlu ditingkatkan dalam setiap pembelajaran matematika interaktif. Oleh karena itu, penelitian ini bertujuan untuk mengetahui bagaimana keterampilan berpikir tingkat tinggi siswa melalui penerapan teori Van Hiele dengan bantuan video animasi. Tahapan berpikir geometris Van Hiele terdiri dari visualisasi, analisis, abstraksi, deduksi, dan ketelitian. Untuk mengaplikasikannya peneliti menggunakan model pembelajaran Thiagarajan yang dikenal dengan Model Four-D. Partisipan yang terlibat dalam penelitian ini adalah siswa kelas sebelas sekolah menengah Islam di Sumatera, Indonesia. Instrumen yang digunakan adalah tes pembelajaran dan LKS. Hasil penelitian menunjukkan bahwa teori Van Hiele dibantu oleh video animasi membantu siswa meningkatkan keterampilan berpikir siswa dan pengalaman siswa mengenai kemampuan mereka untuk memecahkan masalah keterampilan berpikir tingkat tinggi geometris.

Kata kunci: Berpikir tingkat tinggi, Van Hiele, Geometri, Animasi Video

How to Cite: Kairudin, K., Siregar, H., & Siregar, N.H. (2020). Improvement of Students' High Order Thinking Skills (HOTS) Ability through the Application of Van Hiele Theory Assisted by Video Animation, *Journal of Mathematical Pedagogy*, *2* (1), 32-39.

Introduction

According to Regulation of the Minister of National Education (Permendiknas) number 58 of 2014 in appendix III of the Mathematics Subjects Guidelines, one of the goals of mathematics learning is to understand mathematical concepts which are competencies in explaining the interrelationships between concepts and using concepts and algorithms, flexibly, accurately, efficiently, and right (Wardhani, 2016: 20). Mastery understanding of mathematical concepts is important in learning mathematics, because with this understanding will facilitate students in learning mathematics and solving existing problems (Malmia et al, 2019; Nahdi & Jatisunda, 2020).

Quality learning process in class is one of the main factors in achieving success in understanding every subject matter, especially geometry material. The process needs to be reviewed and corrective actions taken to improve the quality of learning in order to achieve learning goals according to the target. However, based on preliminary research, there are still some problems that occur during the

mathematics learning process, such as in learning geometry materials there are still many teachers who only show pictures and shapes of abstract buildings to students (Rizkianto & Zulkardi, 2013; Cumino et al, 2020). For this reason, appropriate action is needed to overcome these problems.

Geometry is a branch of mathematics that deals with the study of different shapes or figures and their properties (Yurniwati & Utomo, 2020). Where the purpose of studying this material are: 1) increase self-confidence and logical thinking, 2) students are able to solve problems, 3) improve spatial intuition 4) reason well, 5) think critically and 6) increase student creativity. In addition, the learning process of geometry can also improve students' higher-order thinking skills.

From a psychological point of view, geometry is the presentation of abstraction from visual and spatial experience, and modeling, such as fields, patterns, measurement and mapping (Alghadari et al, 2020; Nathan, 2020). While from a mathematical point of view, geometry provides approaches to problem solving, creative thinking (higher order thinking) such as diagram drawings, coordinate systems, vectors, and transformations.

The ability to think is something that humans already have. This ability is a mental activity in building and gaining knowledge. This ability can be developed by enriching meaningful experiences through problem solving processes, so that the ability to think can be improved (Lince, 2016). Where this experience will be useful, the students have a concept structure that can be useful for solving problems, reasoning logically, analyzing, and evaluating a problem (Rahman & Ahmar, 2016). One level of thinking ability is the ability to think at a higher level where this ability is an important thing that can be applied in the learning process, including geometry material. The application of higher order thinking skills in learning will cause students to become accustomed to analyzing, reasoning and being creative in solving problems found in life (Pratama & Retnawati, 2018).

But in reality, based on the results of the diagnostic technique obtained, the students' high level thinking ability is still relatively low (Abdullah et al, 2015; Apino & Retnawati, 2017). There are only 21% of students who are able to solve questions at the HOTS level. Besides, they are only able to solve problems of understanding and application. To obtain more detailed data, interviews were conducted with several students regarding their understanding of the questions and learning process in class. The conclusions obtained based on the results of the interview are: Students find it difficult to visualize and draw a cube in a two-dimensional plane, they also find it difficult to imagine building three-dimensional space drawn on a two-dimensional plane, because it does not match the original (Sarama et al, 2003). For example, they thought the base of the cube was a parallelogram. Based on the results of this study it can be concluded that students have difficulty recognizing and understanding geometric shapes, especially geometric shapes and elements.

Spatial geometry learning is active, creative, effective and fun learning if accompanied by the use of interesting learning tools so that students are able to explore concepts so as to trigger higher-order thinking skills (Nutov, 2021). In achieving higher order thinking skills (HOT), students already have lower order thinking skills such as the ability to remember, understand and apply.

The ability to think of each student has different levels from one another. Some studies indicates that students who have the ability to think at a low level and the ability to think at a high level (Friyatmi, 2020). Through learning by using certain actions does not rule out the possibility that there are students who have the ability to think lower level towards higher level thinking abilities. HOTS is a thought process that requires students to be able to manipulate information and ideas in a certain way that can give them new understanding and implications (Gunawan, 2003; Pogrow, 2005). HOTS cognitive domains in the revised edition of Bloom's Taxonomy include the stages of analyzing, evaluating and creating.

Bruner states that if someone learns something knowledge needs to go through certain stages where the knowledge can be internalized in the person's mind (Kadir et al, 2018). This shows that there is a need for learning that has stages that provide opportunities for students to gain meaningful

experiences and lead students to understand concepts more deeply (Kairuddin & Darmowijoyo, 2011). One theory that has stages of learning and is born from problems that occur in geometry classes is Van Hiele's theory (Fuys, 1989). According to Van Hiele three main elements in teaching geometry, namely time, teaching material, and teaching methods applied. If all three elements can be arranged in an integrated manner, it will be able to improve children's thinking ability to higher levels of thinking (Retnawati, 2016; Sugiman et al, 2013). The emphasis of van Hiele's theory is to design learning geometry in hierarchical stages. The stages in van Hiele's theory consist of five sequential stages, namely information, directed orientation, description, free orientation, and integration (Vojkuvkova, 2012).

The steps in learning Van Hiele provide opportunities for students to get meaningful learning with the help of media. Sundayana (2015: 3), revealed that abstract mathematical objects are separate difficulties that students must face in learning mathematics, mathematical concepts can be easily understood by them if they are concrete. This is in line with the opinion of As'ari (1998: 7) that the use of concrete objects by students will make it easier for them to recognize abstract mathematical concepts more simply. The use of instructional media to explain abstract shapes is very important in learning geometry. Thus, the purpose of this paper is to examine how students' high order thinking skills through the application of Van Hiele's theory with the help of animated videos.

Method

Type of research

This is a developmental research which aims to produce a good learning tool, it is necessary to take a certain procedure that refers to one of the development models. The development model used in this study is the Thiagarajan et al. known as Four-D Models. The 4D model was chosen because it is systematic and suitable for developing learning tools. Furthermore Thiagarajan, et al. explained that there are four stages that must be implemented in developing a 4D model device, namely define, design, develop and disseminate (Thiagarajan et al, 1974).

Data Collection and Analysis

Data collection techniques used in this study were the test method and the unstructured interview method. This study uses two instruments, namely the main instrument and supporting instruments, while the main instrument is the researcher himself who functions as a human instrument that is to set the focus of research, choose subjects as data sources, conduct data collection, assess the quality of data obtained, analyze data, interpret and make conclusions and supporting instruments in the form of test questions. The collected data is then analyzed to obtain the desired information by reducing the data, checking the consistency of the data, analyzing the data based on the HOTS indicators in the revised edition of Bloom's Taxonomy, presenting the data in both descriptive and picture form, and drawing conclusions. The conclusion drawing criteria are if the subject is able to solve one of the problems with the level of analyzing, evaluating or creating, then the subject is considered to have reached the HOTS stage, but if the subject is unable to complete one of the problems analyzing, evaluating or creating, then the subject is considered to have not yet reached the stage HOTS This research was conducted in class XII of an Islamic school in the academic year 2019/2020 with a total of 28 students.

Result and Discussion

Developmental Stages

The research begins with designing, testing and revision of the instruments used in this research. Furthermore, learning is done in class with the application of Van Hiele's theory. The steps that are

taken are presented below.

Information Stage

The information stage starts with playing videos of various forms of prism built around the students' daily environment, where students are instructed to name each building. Then a question and answer session was conducted to explore students' initial abilities related to the prerequisite material. Following the revised version of Bloom's Taxonomy, this activity falls into the lowest level that calls remembering. The problems given only ask students to rely on memory.

Orientation Stage

At this stage the teacher displays a video of the changes in the shape of the existing space in students' lives such as rubics and others to form a prism frame, so that the building that looks only looks like a prism frame. Next, students were asked to draw a prism-building model that was displayed, which was a cube on grid paper. By using the cube shape that has been drawn, students are instructed to investigate:

1) The number of parallel sides that Rubik's cube has is ...
2) The number of parallel sides that the cube has is ...
3) The number of perpendicular ribs is ...
4) The number of parallel fields is ...
5) The number of perpendicular fields is ...
6) The number of diagonal spaces is ....
7) The number of diagonal fields ...

Explanation Stage

The teacher displays a video containing pieces of a cube aimed to explain the angular position held by the triangle. The purpose of this activity is students can see which parts have a right angle. Then students are given a problem that contains a triangle that has a right angle with the intention that students can solve the problem using the Pythagorean formula. In explaining this, the teacher gives a question. "If a rubik's cube has a side length of 6 cm, then the length of the diagonal side is ..."

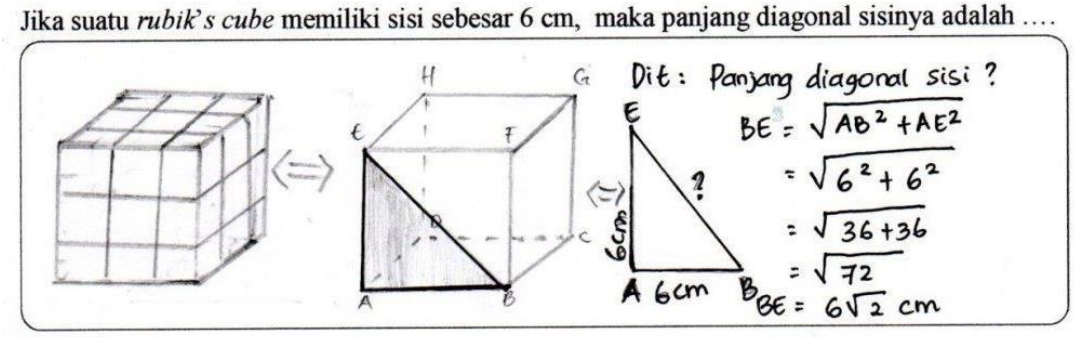

Figure 1. Students' response on a problem (analyzing problem)

This problem is the first level of HOTS namely analyze, where students investigate which side diagonals. Based on the previous stage, namely the orientation phase students can determine which diagonal side, then determine the right angle, the hypotenuse and the right side so that the information obtained they can solve it with the Pythagorean theorem. From the explanation given, students can find the final result, $6\sqrt{2}$ cm.

Likewise, the next question given, the teacher guides students to find the diagonal of space and calculate its length. Students are given the problem "A rubric's cube has a side of 6 cm, then the length of the diagonal space is ...". Student answers can be seen in the picture below.

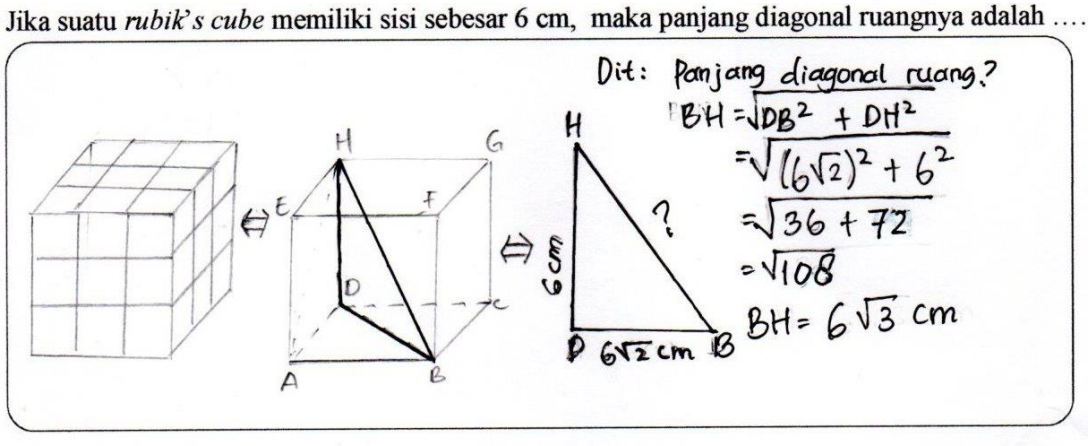

Figure 2. Students' response indicating HOTS level

From this answer, it shows that the students have reached the next HOTS level, which is evaluated, which means to evaluate. Students use rubik's cube on the questions as ABCD.EFGH cube with rib length 6 cm. One of the diagonal spaces of the cube is BH. Students are able to evaluate that, BH has a relationship with the HD rib and diagonal side BD, namely the three sides form a right triangle BDH like the student answers above.

Based on the results of the analysis above, the diagonal length of the rubik's cube space can be obtained by students by calculating the diagonal length of the BH using the phytagorean theorem on the ABH triangle so that a value of $6\sqrt{3}$ cm is obtained as an answer.

Free Orientation Stage

At this stage students are given questions that require high analytical skills. With prior knowledge students are given the opportunity to solve problems provided in their own way. To see this level students are given the problem "Known an ABCDEFGH cube has a side length of 6 cm. If P and Q are respectively located in the middle of the EF and FG sides, the distance between point D and the PQ line is ... "

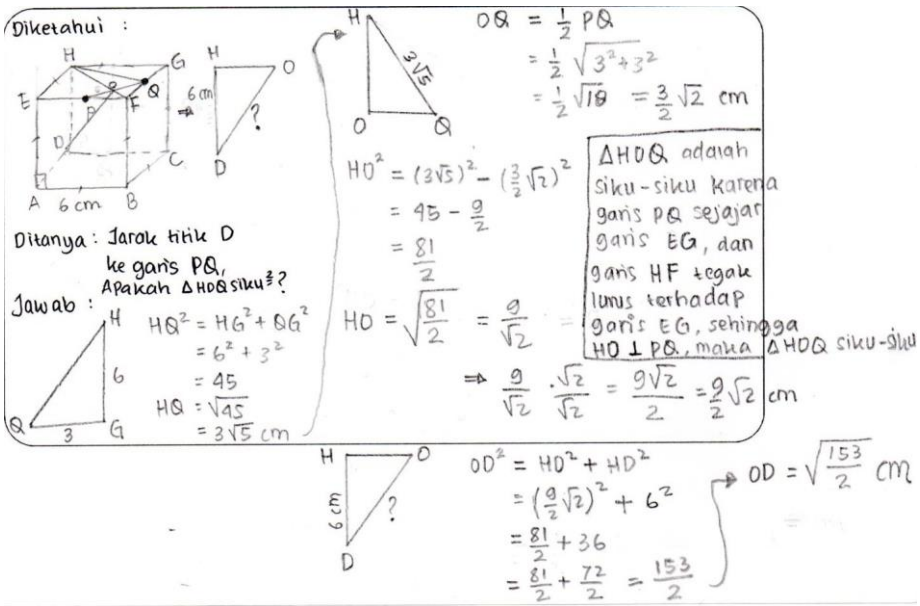

Figure 3. Students' response on a HOTS problem

The highest level in the revised version of Bloom's Taxonomy is creating. This level is indicated by the problem as shown in figure 3. From this student's answer, it can be seen that students try to find the final answer even though they have to go through at least 4 steps of completion before finding the final answer. There is an interesting thing from this student's answer that the reason given by students regarding the HOQ triangle is a right triangle.

Researcher	*: How do you calculate the length of HQ?*
Student	*: I will use the Pythagorean theorem.*
Researcher	*: Why do you use Pythagoras?*
Student	*: Because of the right triangle HOQ.*
Researcher	*: How can you say if HOQ is a right triangle?*
Student	*: Because the PQ line is parallel to the EG line and the HF line is perpendicular to the EG line, so HO is perpendicular to PQ, then the right-angled HOQ triangle.*
Researcher	*: Ok good.*

From this discussion students are able to analyze and create their own ways to solve problems step by step. This can be seen from the picture above the student success to find the final answer. Meanwhile there are other students who find the same results with other paths.

Integration Stage

In this stage students are asked to display their work. From this presentation found that to get their final answers using different way according to their ability to analyze problems and the fastest way to solve problems. In this presentation they were asked to give reasons as to how they found the final answers.

Conclusion

This research has provided information that Van Hiele's theory is able to guide students to understand the topic of spatial geometry. With the help of video, it helps students to explain abstract things about three-dimensional space drawn on two-dimensional space. From the results of this study it can also be seen that following the steps of Van Hiele's theory learning and video assistance can help students to solve problems that require high-level thinking skills (HOTS).

References

Apino, E., & Retnawati, H. (2017, February). Developing instructional design to improve mathematical higher order thinking skills of students. In *Journal of Physics: Conference Series* (Vol. 812, No. 1, p. 012100). IOP Publishing.

Abdullah, A. H., Abidin, N. L. Z., & Ali, M. (2015). Analysis of students' errors in solving Higher Order Thinking Skills (HOTS) problems for the topic of fraction. *Asian Social Science*, *11*(21), 133.

As'ari, A. (1998). Penggunaan Alat Peraga Manipulatif Dalam Penanaman Konsep Matematika. *Jurnal Matematika, Ilmu Pengetahuan, dan Pengajarannya, 27*(1), 5-13.

Alghadari, F., Herman, T., & Prabawanto, S. (2020). Factors Affecting Senior High School Students to Solve Three-Dimensional Geometry Problems. *International Electronic Journal of Mathematics Education*, *15*(3), em0590.

Cumino, C., Pavignano, M., Spreafico, M. L., & Zich, U. (2020). Geometry to Build Models, Models to Visualize Geometry. *Digital Experiences in Mathematics Education*, 1-18.

Friyatmi, M. (2020). Assessing Students' Higher Order Thinking Skills Using Multidimensional Item Response Theory. *Problems of Education in the 21st Century*, *78*(2), 196.

Fuys, D., Geddes, D., & Tischler, R. (1989). The Van Hiele Model of Thinking in Geometry Among Adolescents. *Journal for Research in Mathematics Education Monograph 3: National Council of Teachers of Mathematics*, *37*(2), 53—54. Retrieved from http://www.jstor.org/stable/41193766.

Gunawan, Adi W. (2003). *Genius Learning Strategy Petunjuk Praktis Untuk Menerapkan Accelerated Learning*. Jakarta: Gramedia Pustaka Utama.

Kadir, K., Mulyati, S., & Chandra, T. D. (2018). Penerapan Langkah-langkah Pembelajaran Van Hiele Berbantuan Media Manipulatif sebagai Upaya Meningkatkan Pemahaman Konsep Segiempat Siswa. *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan*, *3*(1), 134-145.

Kairuddin & Darmowijiyo, (2011), *The Indonesian's Road Transportations As The Contexts To Support Primary School Students Learning Number Operation*, *Journal on Mathematic Education*, DOI: https://doi.org/10.22342/jme.2.1.779.67-78

Lince, R. (2016). Creative thinking ability to increase student mathematical of junior high school by applying models numbered heads together. *Journal of Education and Practice*, *7*(6), 206-212.

Malmia, W., Makatita, S. H., Lisaholit, S., Azwan, A., Magfirah, I., Tinggapi, H., & Umanailo, M. C. B. (2019). Problem-based learning as an effort to improve student learning outcomes. *Int. J. Sci. Technol. Res*, *8*(9), 1140-1143.

Nahdi, D. S., & Jatisunda, M. G. (2020, March). Conceptual understanding and procedural knowledge: a case study on learning mathematics of fractional material in elementary school. In *Journal of Physics: Conference Series* (Vol. 1477, No. 4, p. 042037). IOP Publishing.

Nathan, M. J., Schenck, K. E., Vinsonhaler, R., Michaelis, J. E., Swart, M. I., & Walkington, C. (2020). Embodied geometric reasoning: Dynamic gestures during intuition, insight, and proof. *Journal of Educational Psychology*.

Nutov, L. (2021). Integrating visual arts into the mathematics curriculum: The case of pre-service teachers. *Teaching and Teacher Education*, *97*, 103218.

Pratama, G. S., & Retnawati, H. (2018, September). Urgency of higher order thinking skills (HOTS) content analysis in mathematics textbook. In *Journal of Physics: Conference Series* (Vol. 1097, No. 1, p. 012147). IOP Publishing.

Pogrow, S., (2005). HOTS revisited: *A thinking development approach to reducing the learning gap after grade 3*. Phi Delta Kappan, 87(1), 64–75

Rahman, A., & Ahmar, A. (2016). Exploration of mathematics problem solving process based on the thinking level of students in junior high school. *International Journal of Environmental and Science Education*, *11*(14).

Retnawati, H. (2016), *Keefektifan Pemanfaatan Perangkat Pembelajaran Berbasis Masalah untuk Meningkatkan HOTS dan Karakter Siswa. Jurnal Pendidikan Dan Pembelajaran, Volume 23, Nomor 2, Oktober 2016*

Rizkianto, I., & Zulkardi, D. (2013). Constructing Geometric Properties of Rectangle, Square, and Triangle In The Third Grade of Indonesian Primary Schools. *Journal on Mathematic Education*, *4*(2), 160—171. DOI: http://dx.doi.org/10.22342/jme.4.2.414.160-171.

Sarama, J., Clements, D. H., Swaminathan, S., McMillen, S., & Gonzalez Gomez, R. M. (2003). Development of mathematical concepts of two-dimensional space in grid environments: An exploratory study. *Cognition and Instruction*, *21*(3), 285-324.

Sugiman, S. (2013). Students' Competency in Solving and Creating Mathematical Problem in Pre-Service Training Program. *Jurnal Teknologi*, *63*(2).

Sundayana, R. (2015). *Media dan Alat Peraga dalam Pembelajaran Matematika.* Bandung: Alfabeta.

Thiagarajan, S. Semmel, D.S., & Semmel, M. I. (1974). *Instructional Development for Training Teachers of Exceptional Children*. *A Sourse Book*. Indiana: Indiana University.

Vojkuvkova,(2012), The van Hiele Model of Geometric Thinking, *WDS'12 Proceedings of Contributed Papers, Part I, 72–75, 2012.*

Wardhani, S. (2016). *Guru Pembelajar Modul Matematika SMP Kurikulum Matematika*. Jakarta: Direktorat Jenderal Guru dan Tenaga Kependidikan.