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The Effect of Van Hiele Learning Model on Students' Spatial Abilities

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Spatial ability is an ability to visualize an object in space. In learning geometry, the spatial ability is required to solve geometric problems. One of the learning models that can be applied in the learning process to improve students' spatial ability is Van Hiele learning model. Van Hiele learning model is a learning model based on Van Hiele level thinking theory. This research aimed to examine whether the Van Hiele model can give better support to the student's spatial abilities in platonic solid topic. This research was quasi-experiment research with post-test only control group design, which was conducted for one month. The population of this research was the eighth-grade students of junior high school in the Seririt sub-district. By using random sampling techniques, 64 students were chosen as samples and distributed into two classes. The control group was taught by using conventional learning model, while the experimental group used Van Hiele learning model. Data were obtained through essay test for spatial ability at the end of the research. The data were analyzed by using the right side one tailed t-test. The result of the data analysis showed that the mean score of the experimental class was which was higher than the mean score of the control class. Therefore, Van Hiele learning model could give a positive impact to improve students' spatial ability rather than conventional learning.

Keywords: Van Hiele model, spatial ability, platonic solid, Van Hiele's level thinking, geometry learning

INTRODUCTION

Geometry is one branches of mathematics that is taught in primary education until higher education. Based on the mathematics syllabus for junior high school in Indonesia, there are various topics of geometry, including triangle, quadrilateral, Pythagorean Theorem, circle, platonic solid, 3D curve side, similarity, and congruency of a shape. In

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reality, students still have difficulties in understanding the concepts of geometry. Kariadinata (2012) stated that students still have difficulties in solving geometry problem and constructing 3D shapes in general. The result of the national examination for junior high school in the year academic of 2017/2018 showed that the subject absorption for geometry was 41.40 (Kemendikbud, 2018). The result of the mean score of the examination eighth grade students of junior high school in the Seririt sub-district that were algebra was 75.76, statistic 85.71, numeric 80.41 and geometry 51.41 (Administration junior high school in the Seririt sub-district, 2018). It means the absorption rate of geometry was low.

According to Kariadinata (2012) and Pradika & Murwaningtyas (2012), students' difficulty in learning geometry is caused by the lack of spatial ability. According to Permatasari, et. al (2018) the lack of spatial ability of students is caused by internal factors which are having trouble concentrating and lacking the ability to express their ideas. Besides that, the lack of spatial ability of students can also be caused by external factors, including their residential environments and formal education.

By definition, spatial ability is perceptual and cognitive abilities that make someone be able to see spatial relationship (Carter, 2010). According to Linn & Pitersen (1985), spatial ability is a mental process in preserving, recalling, generating, transforming, and communicating solid. Maier (1996) said that spatial ability is an abstract concept that consist of five elements, which are (1) Spatial Perception, the ability to perceive an object both vertically and horizontally; (2) Spatial Visualisation, the ability to visualize the motion of a solid; (3) Mental Rotation, the ability to determine the position of an object after rotation by a specific direction; (4) Spatial Relation, the ability to understand the elements of an object and the relation between one element to the other element; and (5) Spatial Orientation, the ability to maintain our body orientation to the surrounding environment both physically and mentally.

Spatial ability needs to be improved in learning mathematics, especially in platonic solid topics. Spatial ability is required in learning geometry. It is supported by the study conducted by Tessema (2018), which stated that spatial ability gives a significant effect to the geometric ability of primary students in Ethiopia and contributes as much as 29.90% of all variables that determine the geometric ability. However, generally, it was not a concern for the teacher when giving lesson at school as the focus is to provide the information to be memorized (Syahputra, 2011).

Based on the explanation above, innovation is required in the learning process. One of them is to apply a learning model that is specifically designed for learning geometry; thus, students can be mentally involved in the learning process to improve their spatial ability. Van Hiele learning model is a learning model based on Van Hiele's levels of thinking. In Van Hiele learning model teachers have to observe students' readiness in receiving the lesson, such as the students' attitude, enthusiasm, and physiology.

Van Hiele (1986, in Clements & Battista, 1992) also stated that there are five phases that have to be done by teachers to teach geometry in classroom. The steps are Inquiry, Guided Orientation, Explanation, Free Orientation, and Integration. In learning geometry, students have to pass one phase before advancing to the next phase. According to Parwati, et. al. (2018), in designing and carrying out the learning process, teachers have to focus on the cognitive progress of the students. Hence, Van Hiele learning model is appropriate to be applied in learning especially geometry.

Applying Van Hiele learning model phases can help students to understand the basic concept of geometry. The syntax of Van Hiele learning model is related to the effort of improving students' spatial activities. First, in Inquiry, the students are given a concrete object of a solid that help the students to visualize the geometrical object. Kelly (2006) stated manipulative objects can help the students to understand the abstracts geometrical concepts. Also, in this step, the teacher and the students are doing question and answer session about the topic to examine students' initial understanding.

Second, in Guided Orientation, the students will observe the specific characteristics of the given objects to evaluate the relationship among its elements. Third, in Explanation, the students explain what they have discovered and teachers give clarifications if needed and ask questions to check their understanding and visualization abilities. Fourth, in Free Orientation, the students use their spatial abilities to solve a problem. Finally, in Integration, the students review and recall the material they have learned.

Several researchers stated that Van Hiele learning model is effective to be applied in teaching geometry to the students. A research conducted by Al-ebous (2016) to the children of 5-11 years old in a primary school at Jordan stated that students who had been taught by Van Hiele learning model had a better understanding of geometric concepts than those who had been taught by conventional learning method. According to Ramlan (2016), the level of the geometric thinking and self-efficacy of SMA Negeri 1 Wundulako who had been taught by Van Hiele learning model were higher than those who had been taught by conventional learning method. According to Hendroanto (2016), spatial ability and Van Hiele level thinking gave a positive impact to improve High Order Thinking Skills on geometry of the college students in Ahmad Dahlan University.

Based on the aforementioned explanations, it could be predicted that the spatial ability of students who had been taught by Van Hiele learning model was better than those who had been taught by conventional learning. Differences from earlier studies that only looked at the effect of the Van Hiele model on the geometry level thinking, this study showed the effect of Van Hiele learning model on students' spatial ability. Therefore, the present study was interested to conduct further research about "The Effect of Van Hiele Learning Model on Students' Spatial Abilities".

Research Question

Do the students' spatial abilities who have been taught by using Van Hiele learning model higher than those who have been taught by conventional learning?

Objectives Research

To examine whether the Van Hiele model can give better support to the student's spatial abilities in platonic solid topic.

LITERATURE REVIEW

Van Hiele Learning Model

Van Hiele learning model is learning model based on Van Hiele's theory of levels of thinking in learning geometry. According to the theory, the students cannot move to the higher level if they have not passed the lower level. Clements & Battista (1992) states that there are five levels of thinking based on Van Hiele's theory, those are: (1) Visualization: In this phase, students could recognize geometry objects through observation. Students have been able to recognize the names of geometry objects, but don't know their properties; (2) Analysis: In this phase, the students have been known the properties of the geometry objects but couldn't explain the relation of the objects; (3) Abstraction: In this phase, the students have been able to make a conclusion and arrangement; (4) Deduction: In this phase, students have been able to make a conclusion deductively that makes a conclusion from general to specific; and (5) Rigor: In this phase, the students have been able to understand formal deduction aspects such as establishment and comparison mathematics system. The progress of thinking geometry of each student is different, it depends on the learning experience that they have. Van Hiele mentioned there are several learning phases in learning geometry. According to van Hiele (1986), cognitive progress in geometry can be accelerated by instruction and there are five phases in the teaching process which promote students' progress from one van Hiele level to the next level in geometry classroom. The five phases are:

(1) Inquiry/Information: In this step, the teacher identify students' initial understanding of geometry. The characteristics of this phase included: observations are made; questions are made; teachers learn students' prior knowledge; students gain direction; ideas are introduced for students to think about.

(2) Guided Orientation: In this step, the teacher explores the field of investigation using the material, for example, by folding, measuring, and looking for symmetry. The characteristics of this phase included: activities that should reveal geometric structures characterized by the level; students are actively engaged in exploring and manipulating objects.

(3) Explanation: In this step, students explain what they have discovered and the teachers will give clarification if needed and ask questions to check their understanding and visualization abilities. The characteristics of this phase included: the teacher role is minimal, but uses questioning techniques to draw out student thinking; the teacher should draw distinctions between the common usage of vocabulary and its mathematical usage.

(4) Free Orientation: In this step, students are directed to solve their problems by applying what they have improved. The characteristics of this phase included: students find their own ways of solving problems; the teacher's role is to select appropriate problems with multiple-solution pathways and to encourage students to reflect and elaborate.

(5) Integration: In this step, students review and recall the material they have learned. The characteristics of this phase included: teacher can furnish global summaries to help students synthesize concepts but should not present anything new; the emphasis is on students understanding mathematical structures.

Spatial Ability

In learning geometry, especially three-dimensional objects, it is required to have dimensional ability to visualize an abstract geometric object into a two-dimensional plane. Clements (1998) defines spatial ability as a mental operation in organization or forming an object or collection of objects. According to Gardner (1987), the dimensional ability mentioned before is called spatial ability. According to Linn & Petersen (1985), spatial ability is a mental process in preserving, recalling, generating, transforming, and communicating solid. Mc Gee (1979, in Priatna, 2017) spatial ability divides into two types those are: spatial visualization and spatial orientation. Spatial visualization is the ability to imagine, manipulate, spin, rotate, or flip objects without referring to a person. Spatial orientation is the ability to imagine the appearance of the objects from different perspectives. Meanwhile, Maier (1996) divides the spatial abilities into five types those are: (1) Spatial Perception, i.e. the ability to imagine the vertical and horizontal fixation of direction of the geometry objects regardless of troublesome information. The tests that can be used to measure the spatial perception is water level test and road and frame test; (2) Spatial Visualization, i.e. the ability to describes the situation when the objects are moving. One of the tests that can be used to measure the spatial visualization is determineing the right nets for geometry objects; (3) Mental Rotation, i.e. the ability to rotate 2D and 3D objects accurately and quickly. The test that can be used to measure this ability is determining the right position which has been rotated; (4) Spatial Relation, the ability to understand the elements of an object and the relation between one element to the other element. One of the tests that can be used to measure this ability is determining the objects which have resemblance with the others objects; and (5) Spatial Orientation, i.e. the ability entering into a given spatial situation. The test that can be used to measure this ability is being able to imagine the shape of an object when viewed from different perspectives.

METHOD

Research Design

This present research was a quasi-experiment with post-test only control group design. The population of the research was the eighth students of junior high school in the Seririt sub-district. By using a random sampling technique, 64 students were selected as sample in the study. Before determining the control and experiment classes, the equality of the sample classes was performed by examining the result of final test in the previous semester using two- tailed t-test. The result showed that the two classes have an equal ability. Then, we randomly assigned the class into experimental class (n = 32) which taught by using Van Hiele learning model and Control class (n = 32) which taught by using conventional learning. Difference the learning phases in experimental class and control class explained in Table 1.

Table 1
Learning Phases in Experiment Class and Control Class

Number	Van Hiele Learning Model	Conventional Learning
1.	*Inquiry Phase* - *The teacher gives a concrete object to the students and uses GeoGebra to represent a geometric object.* • *The students observe the concrete object given by teacher* - *Teacher gives a question about the object.* • *The student provided an answer towards the teacher's question.*	*Introducing the new material and gives a motivation to students* - *The teacher explains about a new material and gives motivation to students.* • *The students listen to the teacher's explanation and* ask the teacher if the explanation is not clear.
2	*Guided Orientation Phase* - *The teacher asks students to examine the characteristics of the given geometry object.* • *The students examine the characteristics of the given geometry object.* - *The teacher asks the students to discuss the problem in worksheet and provides guidance* • *The students discuss the given problem.*	*Organizing the students into study groups* - *The teacher helps the students to establish study groups.* • *The students establish a study group according to the teacher's direction.*
3	*Explanation Phase* - *The teacher asks the students to explain their discussion result about the problem given.* • *The students explain the discussion result about the given problem.*	*Providing a guidance to each group* - *The teacher asks the students to work in pairs with their study groups.* • *The students discuss the problem in worksheets with their study groups.*
4	*Free Orientation Phase* - *The teacher gives open-ended problems to the students* • *The students answer the problem given by the teacher.*	*Evaluation* - *The teacher asks students to explain their discussion result about the given problem and gives a clarification if needed.* • *The students explain the discussion result about the given problem*
5	*Integrate Phase* - *The teacher asks the students to give a review about the lesson.* • *The students give a review about the lesson.*	*Giving feedback* - *The teacher gives feedback to the students who were active in discussion.* • *The students receive the teachers' feedback.*

(Modified from Hayati, 2017 and Clement & Batista, 1992)

Instruments and Procedures

The students' spatial ability assessed through essay test based on five types spatial abilities according to Maier (1996) which are: (1) Spatial Perception, (2) Spatial Visualisation, (3) Mental Rotation, (4) Spatial Orientation, and (5) Spatial Relation shown in the Table 2 below.

Table 2
Indicator of Spatial Ability Test

Spatial Type	Spatial Indicator	Question Indicator
Spatial Perception	The students are able to perceive an object both vertically and horizontally	• Given a picture of a vessel filled with water placed on the flat plane, students are asked to draw a surface of the water if the vessel's position is manipulated. • Given a platonic solid, students were asked to draw and mention diagonal plane from the platonic solids.
Spatial Visualisation	The students are able to visualizing the motion of a solid	• Determine which nets are appropriate to construct platonic solids.
Mental Rotation	The students are able to determine the position of an object after rotation by a specific direction	• Given a platonic solid, students are asked to draw the position after the object was rotated.
Spatial Relation	The students are able to understand the elements of an object and the relation between one element to the other element	• Determine the volume or surface of platonic by looking the relationship or pattern of a geometric problem.
Spatial Orientation	The students are able to saw the shape of an object when viewed from a different perspective.	• Determine the shape of an object when viewed from a different perspective. • Determine the number of unit cubes affected by the paint from the cube sequence.

(Modified from Maier,1996)

To check the content validity of the instrument, the expert judgments' test by two lectures in Mathematics Education Study Program, Universitas Pendidikan Ganesha, was conducted. The result was analyzed using Gregory formula and it was measured that the content validity score of the instrument equal to 1. It means the instrument was worthy to test the students' spatial ability. Furthermore, the instrument was tested by using Alpha Cronbach and it was found that the instrument was reliable.

Data Analysis

Students' spatial ability was measured by a post-test at the end of the lesson. The data were analyzed using right side one tailed t-test to know whether the spatial ability of the students who were taught by using Van Hiele model was higher than those who were taught by using conventional learning.

FINDINGS

The result of the five types of spatial ability of the student in the experiment and control class were shown in Figure 1 below.

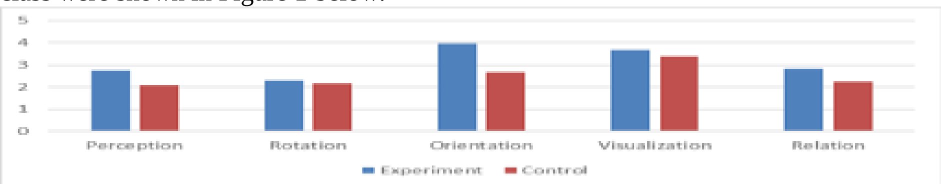


Figure 1
The Mean of Score Experiment and Control Class based on Five Types of Spatial Ability

Based on Figure 1, the mean of scores of experiment class based on five types of spatial ability was higher than the control class. The students' spatial abilities obtained from the post-test results for the two sample classes are shown in the following Table 3.

Table 3
Summary of Data Analysis Results of Students' Spatial Ability

Number	Variable	Class sample	
		Experiment	Control
1	Number of students	32	32
2	Mean Score	15.2813	12.6563
3	Variance	2.218	3.107

The data in Table 3 showed that the mean score of students' spatial abilities on platonic solid that were taught by using Van Hiele learning model was higher than students who were taught conventionally.

The prerequisite test was conducted before the hypothesis test. The prerequisites were normality test and homogeneity test. Normality test with Kolmogorov-Smirnov test at 5% significance level showed that the students' spatial abilities on the two sample classes was normally distributed. Then for the homogeneity test of variance with Levene test, it gained the value of W=1.994 and F_{table} = 3.996. Since the value of W less than F_{table} it could be concluded that the data of students' spatial abilities on the two sample classes had homogeneous variance.

Since the data was normally distributed and had a homogeneous variance, the hypothesis could be tested by using right side one tailed t-test. The summary of the result could be seen in Table 4.

Table 4
Summary of T-Test Result of Students' Spatial Abilities

Class sample	Number of Students	Average grade	Variance	t_{score}	t_{table}
Experiment	32	15.2813	2.699	3.890	1.669
Control	32	12.6563			

Based on table 4, the value of t_{score} was higher than t_{table} in significance rate of 5%. Therefore, the spatial ability of students who were taught by using Van Hiele model was higher than those who were taught using conventional learning.

DISCUSSION

The five phases leaning of the Van Hiele learning model be able to help the students improve their spatial abilities. The result is also supported by a study conducted by Ruslan & Salan (2014), which stated that the phases in Van Hiele learning model strongly emphasize students to understand geometrical concepts based on the obtained information and to redefine the concepts using their own understanding.

In Inquiry phase, the students were given concrete objects and learning media to help them represent abstract geometrical objects. Kelly (2006) said manipulative object will support the students to understand the abstract concepts in mathematics. In this phase, the teacher and students also conducted question and answer session to explore students' initial knowledge about the concepts. By knowing the initial knowledge students, teacher will be able to choose suitable steps to teach the students further (Kadir, et. al., 2018).

In Guided Orientation phase, the students were guided by the teacher to observe the characteristics of the elements of the given solid and they had drawn the two-dimension version of the given solid. For example, in the worksheets, the students were given a problem and asked to describe the nets formed, as shown in the following Figure 2.

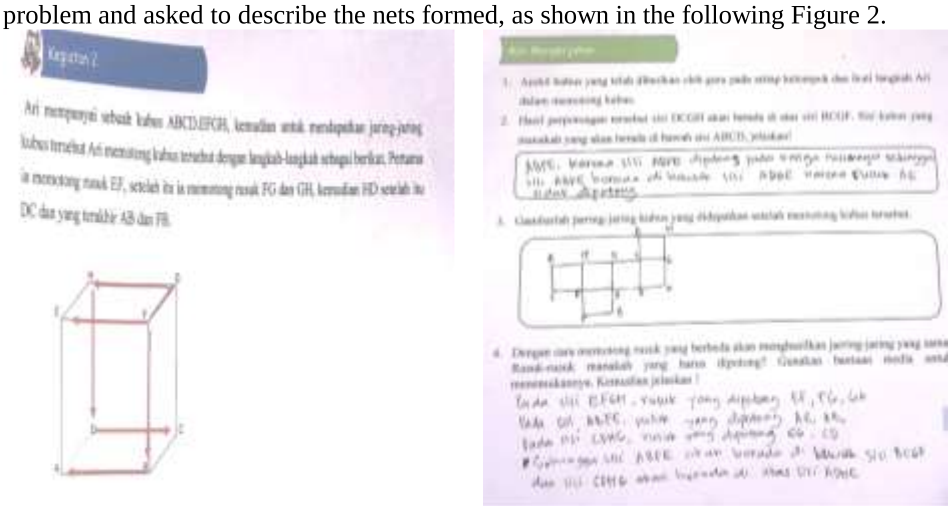


Figure 2
Students' Worksheet in Guided Orientation

Activity 2
Ari has a cube ABCD. EFGH, then to get it net, she cut the cube with the following steps. First, she cut the edge EF then the edges FG and GH. After that, she cut the edge HD followed by DC. Last, she cut AB and FB.

Let's Work
1. Take the provided cube and cut as in Activity 2.
2. The result of activity 2 will bring the side of DCGH above BCGF. Determine and explain which side will be below ABCD.
ABFE, since the side ABFE were cut in its three edges. Hence, the side ABFE will be under ADHE since the edge of AE were not cut.
3. Draw the nets of the cube you got in Activity 2.
4. With different cutting techniques, same nets will be produced. Which edges should be cut? Use the media to help your exploration, then explain your answer.
In EFGH, cut EF, FG and GH
In ABFE, cut AE and AB
In CDHG, cut CG and CD
Hence, ABFE will be under BCGH and CDHG will be above ADHE.

Figure 3
Guided Orintation phase

In this phase, students started to practices their spatial abilities. The learning's aim in this phase was to stimulate the students to explore the objects to find the relation of the characteristic of the solid. In Figure 2, students were asked to cut and fold the given concrete objects to produce the desired nets, these activities could enhance their spatial ability. It was in accordance with the research conducted by Wardhani, et al (2016) which states that using origami, students' skill to fold and cut to form a shape could improve students' spatial abilities.

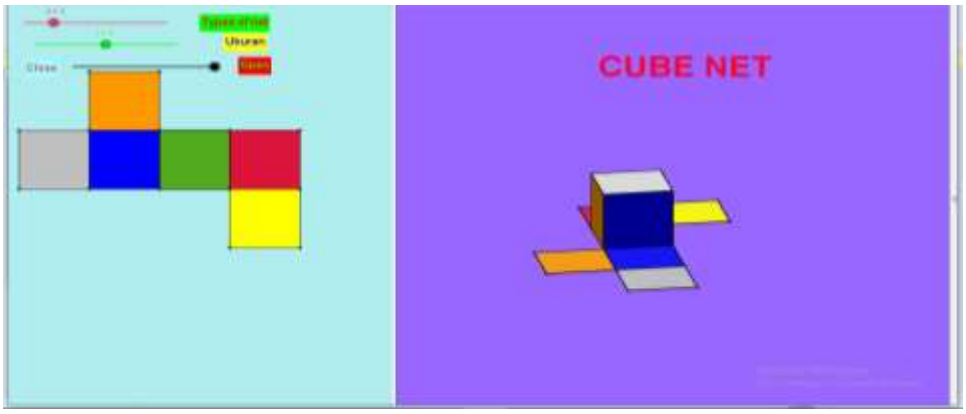
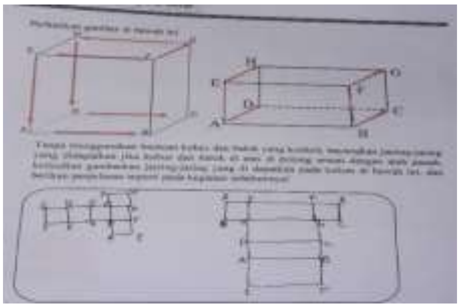


Figure 3
GeoGebra media to Represent Cubes

After exploring the characteristic in Explanation phase, the students were asked to explain their findings in the previous phase by using their own words. By that, they could improve their understanding about the material. It was supported by Lomibao (2016), who stated the students were challenged to communicate both verbally and written in mathematics class which helped them to expand their understanding to the concept.

As shown in Figures 3 and 4, the students were given a problem with cube nets, then determining the ribs that must be cut to form the nets. By using media assistance with the GeoGebra application, the students provided explanation about their findings. According to Jelatu, et. al. (2018) learning with GeoGebra could improve students' abilities to understand geometric concepts and geometrical spatial, both in students whose spatial abilities were high and low. This was due to the fact that GeoGebra was providing an optimal learning environment for the students.

In the Free Orientation phase, students were given open-ended problems to practice them to use their spatial ability in solving problems. For example, as shown in Figure 5, the students were asked to find the nets of the cube in which edges were cut in a certain direction without using the help of a concrete object or a media. Providing students with problems using an open-ended approach be able to improve their spatial abilities. This was in line with the research conducted by Priatna (2017) which stated that by using an open-ended approach, the students could find the concepts that are being taught and solve more complex problems so they can improve their spatial abilities.



Consider the following figure.
Without using concrete object, imagine the nets of the cube and rectangular prism above which are cut based on the arrow direction. Then, draw and explain it below.

Figure 4
Free Orientation Phase

In the last phase, students were conclude about what they have learned and discovered about platonic solid. Differences from the earlier study, in this study, it had a new finding that Van Hiele learning model indirectly also improve the level of geometrical thinking of the students. As seen in Figure 1, the mean of the score in the experiment class was higher than in the control class for orientation and visualization. It indicated that Analytic Level (level 1) for the experiment class was higher than the control class. Also, the mean scores of the experiment class was higher than the control class for spatial relation and perception. It indicated that the Informal Deduction (level 2) for the experiment class was higher than the control class. Moreover, the mean of the scores of the experiment class was higher than the control class for mental rotation. It indicated the Deduction (level 3) for the experiment class was higher than the control class.

The results were supported by the previous research that stated the student in level 0 had not been able optimally to use their spatial abilities (Nur et. al., 2019). Meanwhile, the students in level 1 were only able to use their spatial abilities for visualizing and perceiving. Furthermore, the students in level 2 were able to use their spatial abilities for visualizing, perceiving, and orientating. Last, the students in level 3 were able to use their spatial ability for visualizing, perceiving, orientating, and rotating. The relationship between spatial abilities in Van Hiele thinking level and Van Hiele phases were shown in the following Table 5.

Table 5
The Relationship between Spatial Ability, Van Hiele's Level Thinking, and Van Hiele Phases

Spatial Ability	Van Hiele's Level Thinking	Van Hiele Phase	Learning Activities
	Level 0 (Visualization)	Inquiry	Students are given a concrete object and asked to determine the shape of the object.
Orientation Visualization	Level 1 (Analysis)	Inquiry Guided Orientation	Students are asked to mention the characteristic of the concrete objects that were given.
Visualization Relation Perception	Level 2 (Informal deduction)	Guided Orientation Explanation Free Orientation	Students are asked to draw the concrete object, mention the difference between one object and another object, and determine the relation between one object and another object
Rotation	Level 3 (Deduction)	Guided Orientation Explanation Free Orientation Integration	Students are given open-ended problems and then asked to explain the finding and give a review

Those five learning phases had given a positive impact on improving the spatial ability of the students. From the explanation above, Van Hiele learning model was able to improve students' spatial abilities. This was also in line with the previous research conducted by Herman, et al. (2016) which stated that the geometrical ability of the students who were taught by using Van Hiele learning model was higher than those who were taught by using scientific methods. As modification of Herman's research, in his study, the Van Hiele learning model was combined with scientific method so that it's more effective in improving students' spatial abilities. According to a study conducted by Sari (2016), a learning device based Van Hiele theory could increase the students' visual spatial intelligence. From 20 students that were being investigated, 85% could identify the meaning of the cube nets, 55% could identify the cube nets, and 60% could draw the cube nets. The scope of the study of Sari (2016), however only for the spatial visual ability. Meanwhile, in this study, the five types of spatial abilities of students could be improved.

CONCLUSION

Based on the result of this study, it could be concluded that learning activities in Van Hiele model class had an effect for increasing students' spatial abilities. It was shown by the research of the spatial test of the students who were taught using Van Hiele learning model was better than the students in conventional learning. The activities conducted in five-phase Van Hiele learning model allowed the students to practice and enhance their spatial ability. Moreover, the students gained enjoyable learning activities and were able to practice their creativity using concrete objects and media manipulatives. It is expected to educational practitioners especially those involved in learning mathematics to use Van Hiele model as one of the innovative teaching models in order to provide more opportunities for the students to enhance their spatial ability and also develop learning tools that can help improve students' spatial abilities based on Van Hiele theory.

REFERENCES

Al-ebous, T. (2016). Effect of the Van Hiele model in geometric concepts acquisition: The attitudes towards geometry and learning transfer effect of the first three grades students in Jordan. *International Education Studies*, *9*(4), 1-17.

Carter, P. (2010). *Tes IQ dan Bakat: Menilai Kemampuan, Penalaran Verbal, Numerik dan Spasial Anda*. IQ and talent test: Evaluate your ability, verbal reasoning, numeric, and spatial ability. Jakarta: PT Indeks.

Clements, D. H., & Battista, M. T. (1992). Geometry and spatial reasoning.In D. A. Grouwa (Ed.), *Handbook of research on mathematics teaching and learning* (pp.420-464). New York : Macmillian.

Gardner, H. (1987). The theory of multiple intelligences. *Ann of Dyslexia*, *37*(1), 19–35.

Hayari, S. (2017). *Belajar dan Pembelajaran Berbasis Cooperative Learning*. Study and Learning Based on Cooperative Learning Jakarta: PT Graha Cendekia

Herman, Fahinu, & Makkulau. (2016). *Pengaruh Model Pembelajaran Van Hiele dan*

Pembelajaran Scientific terhadap Kemampuan Penalaran Geometris Berdasarkan Self-Efficacy Siswa Sekolah Menengah Pertama. [The Effect of Van Hiele Learning and Scientific Learning Model on Geometric Reasoning Ability]. *Jurnal Pembelajaran Berpikir Matematika*, *1*(1), 41–50.

Jati Sari, D. O. (2016). *Pengembangan Prototipe Perangkat Pembelajaran Geometri Materi Bangun Ruang Berdasarkan Model Van Hiele untuk Sekolah Dasar*. [Development of Prototype Geometry Learning Devices to 3D Shapes for Primary School]. *Essay at Sanatha Dharma University.*

Jelatu, S., Sariyasa, & Ardana, I. M. (2018). Effect of geogebra-aided REACT Strategy on understanding of geometry concepts. *International Journal of Instruction*, *11*(4), 325–336.

Kadir, K., Mulyati, S., & Chandra, T. D. (2018). *Penerapan Langkah-langkah Pembelajaran Van Hiele Berbantuan Media Manipulatif sebagai Upaya Meningkatkan Pemahaman Konsep Segiempat Siswa.* [The effectivieness Van Hiele Learning Model Assited Manipulative Media to Improve Student's Understandin on Rectangular]. *Jurnal Pendidikan*, *1*, 134–145.

Kelly, C. (2006). Using manipulatives objects in mathematical problem solving: a perfomance-based analysis. *The Montana Mathematics Enthauasiast*, *3*(2), 184-193.

Kemendikbud. (2018). *Laporan Hasil Ujian Nasional*. National Examination Report. Retrieved from Puspendik. Kemendikbud website: https://puspendik.kemdikbud.go.id/hasil-un/.

Linn, & Pitersen. (1985). Emergence and characterization of sex differences in spatial ability. *Child Development*, *56*(6), 1479-1498.

Lomibao, L. S. (2016). The influence of mathematical communication on students' mathematics perfomence and anxiety. *American Journal of Education Research*, *4*(5), 378-382.

Maier. (1996). Spatial geometry and spatial ability. How to make solid geometry solid? In E. Cohors-Fresenborg, K. Reiss, G. Toener, & H.-G. Weigand (Eds.), Selected Papers from the annual conference of didactics of mathematics (pp.63-75). Osnabrueck.

Nur, E., Rinaldi, Z., & Hermanto, R. (2019). *Proses Berpikir Peserta Didik Ditinjau Dari Kemampuan Spasial Berdasarkan Level Berpikir Van Hiele*. [Students' thinking Process in terms of Spatial Ability Based On Van Hiele's Level Thinking]. *Journal of Authentic Research on Mathematics Education (JARME), 1*(1), 38-45.

Parwati, N. N., Suryawan, I. P. P., & Apsari, R. A. (2018). *Belajar dan Pembelajaran*. [Study and Learning]. Singaraja: PT RAJAGRAFINDO PERSADA.

Permatasari, I., Pramudya, I., & Kusmayadi, T. A. (2018). Spatial ability of slow learners based on Hubert Maier theory. *Journal of Physics: Conference Series, 983*(1), 012095.

Pradika, L. E., & Murwaningtyas, C. E. (2012). Analisis Kesalahan Siswa Kelas VIII SMP N 1 Karanganyar Dalam Mengerjakan Soal Pada Pokok Bahasan Bangun Ruang Sisi Datar Serta Upaya Remediasinya dengan Media Bantu Program Cabri 3D. [Analysis of Students' Mistakes in Grade Eight Students of junior high school Karanganyar in Platonic Solid]. *Prosiding Seminar Nasional Matematika dan Pendidikan Matematika Jogjakarta*, *8*(7), 978–979.

Priatna, N. (2017). Students' spatial ability through open-ended approach aided by cabri 3D. *Journal of Physics: Conference Series*, *895*(1), 012065. https://doi.org/10.1088/1742-6596/895/1/012065.

Rahayu K. (2012). *Kemampuan Visualisasi Geometri Spasial Siswa Madrasah Aliyah Negeri (Man) Kelas X Melalui Software Pembelajaran Mandiri.* [Visualization Ablities of Spatial Geometri of Students]. *Jurnal Edumat*, *1*, 1-13.

Ramlan, A. M. (2016). The effect of van hiele learning model toward geometric reasoning ability based on self-efficacy of senior high school students. *Journal of Mathematics Education*, *1*(2), 64–71.

Ruslan, & Salan, M. (2014). *Pengaruh Model pembelajaran Van Hiele terhadap Penalaran Geometris Siswa Kelas IX SMP Negeri 2 Kendari.* [The Effect Van Hiele Learning Model on Student's Geometry Reasoning]. *Jurnal Penelitian Pendidikan Matematika*, *2*(9), 1–16.

Syahputra, E. (2011). *Peningkatan Kemampuan Spasial dan Disposisi Matematis Siswa SMP dengan Pendekatan PMRI pada Pemebelajaran Geometru Berbantuan Komputer*. [Improvement of Students' Spatial Ability and Mathematical Disposition with RME Approach to Computer-Aided Geometry Learning]. Bandung.

Tessema, G. (2018). The relationship among spatial ability, van hiele level, and students' academic performance in geometry the case of upper primary school students in fitche town, ethiopia abstract. *Intenational Journal of Inovative Research and Development* , *7*(12), 52–57.

Wardhani, D., Irawan, E. B., & Sa'dijah, C. (2016). O*rigami Terhadap Kecerdasan Spasial Matematika Siswa.* [Origami on Student's Spatial Intelligence in Mathematics]. *Jurnal Pendidikan*, *1*(5), 905–909.