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Geometric Thinking Level of Vocational High School Based on Van Hiele's Theory Viewed from Gender and Mathematical Ability

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Abstract: The purpose of this study is to describe the level of geometrical thinking of Vocational High School students based on Van Hielle's theory in terms of gender differences. This study used a qualitative approach involving six students of Vocational High School as research subjects consisting of three male students and three female students with different mathematical abilities. The results of this study state that there is no striking difference between the level of geometrical thinking of male and female students who are the subject of research, i.e. all are at the level of thinking one (analysis). Likewise, when viewed from different mathematical abilities, it turns out to be apparent at the level of thinking one, except for one student in the moderate mathematics ability degree who is at the level of zero thinking (visual) because this subject has a low geometry thinking ability. The ideal level of thinking for vocational high school students, the level of thinking two (Abstraction), is not reached. In addition, the lower the level of mathematical ability, the less the indicator is satisfied at the same level of thinking.

Key Words: geometrical thinking ability, Van Hiele's theory, gender difference

Abstrak: Tujuan penelitian ini untuk mendeskripsikan tingkat berpikir geometri siswa Sekolah Menengah Kejuruan berdasarkan teori Van Hielle ditinjau dari perbedaan jenis kelamin. Penelitian ini menggunakan pendekatan kualitatif dengan melibatkan enam siswa Sekolah Menengah Kejuruan sebagai subjek penelitian yang terdiri atas tiga siswa putra dan tiga siswa putri dengan kemampuan matematika berbeda. Hasil dari penelitian ini menyatakan bahwa tidak ada perbedaan yang mencolok antara tingkat berpikir geometri siswa putra dan putri yang menjadi subjek penelitian, yaitu semua berada pada tingkat berpikir satu (analisis). Demikian juga jika ditinjau dari kemampuan matematikanya berbeda ternyata semua pada tingkat berpikir satu, kecuali pada seorang siswa kelompok kemampuan matematika sedang yang berada pada tingkat berpikir nol (visual) karena subjek ini memiliki kemampuan berpikir geometri rendah. Tingkat berpikir ideal untuk siswa seusia Sekolah Menengah Kejuruan, yaitu tingkat berpikir dua (Abstraksi) tidak tercapai dan semakin rendah tingkat kemampuan matematikanya semakin berkurang indikator yang terpenuhi pada tingkat berpikir yang sama.

Kata kunci: tingkat berpikir geometri, teori Van Hiele, perbedaan jenis kelamin

INTRODUCTION

The challenges of life in the future are getting harder, education is expected to prepare gen erations who are able to face those challenges. Therefore, the government promotes the development of Vocational High School (SMK) programs in the hope that when they graduate from school, students will be able to face the world of work. Vocational students are expected to be able to answer the challenges of life in the future which is increasingly complex and full of competition, not just mastering subject matter at school but also be able to apply and develop the subject matter in the world of work.

Education Level Unit (KTSP) curriculum in Vocational High Schools in addition to containing productive subjects which are the core of learning, there are other subjects given to support them. The lessons given can be grouped in adaptive, normative and pro-

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ductive lessons. In groups, normative subjects include exact and non-exact subjects. Mathematics is one of the exact lessons given in vocational schools and other public schools and it is better known as school mathematics. According to Soedjadi (Karimah, 2013), school mathematics is the parts of mathematics chosen on the basis of developing students' abilities and personalities and responding to the demands of an evolving environment which is in line with advancement of science and technology.

In SMK curriculum, with the existence of school mathematics, students are expected to not only be skilled in doing math problems but also be able to apply them in the real world. Soedjadi (Karimah, 2013) revealed the purpose of teaching mathematics at every level of education refers to formal and material. Formal goals emphasize more on structuring reason and forming children's attitudes. Whereas, material goals emphasize more on solving problems, arithmetic skills and the application of mathematics. Students are not only able to solve mathematical problems in school, but also apply it to the real world, thus they can develop the ability to think logically, systematically and critically and become a human builder who is diligent, creative, intelligent and responsible.

Mathematics when associated with the world of work has many benefits, for example geometry material which is needed when operating a CNC (Computer Numeric Control) machine. Hartanto (2015) conducted a study of factory employees in Batam with a background of vocational and high school graduates stating that geometric accuracy is one of the important factors in the operation of CNC machines, especially during setting time. It can be seen that in the machining process, especially during setting time, there are still materials that do not fit the expected dimensions. This is influenced by employees who are not careful in using their geometrical capabilities.

Students still have low achievement in Geometry, so geometry is considered as one of the difficult subjects. Soedjadi (Nurjannah et al, 2017) also revealed that the Geometry unit is a unit of mathematics that is quite difficult. The results of Herawati's research (Suryantono, 2013) concluded that the fifth grade elementary school students had not mastered geometrical problems as listed in the curriculum. Hadiyan (2007) revealed that most junior high school students have weaknesses in using improper properties to distinguish, identify, and choose geometric shapes. Likewise, the results of Ponter's research (Rahayu, 2016) concluded that geomery is a concept that has not been mastered by students. Basuki's research (Hidayati, 2017) also revealed that students experienced difficulties when answering new geometry problems, lacked understanding of the concept of circles and had difficulty remembering formulas.

One of the geometry materials in class XI Vocational School is geometric objects. Before learning to geometric objects, students must first understand the material of geometric shapes, one of which is square. Geometry material is also a prerequisite material which is very important and relevant to productive material in Engineering Technology major, especially with technical drawing material. Geometry is also closely related to material drawing patterns in the Boutique Clothing department. If you do not master geometry, students will have difficulty in mastering productive material in their respective majors.

Based on the initial research at SMK 1 Grogol, 5 students were given geometry problems to analyze students' way of thinking errors. The five students were given a picture of a square and were asked to justify that the square was a parallelogram, as in Figure 1. From the results of this study, it was concluded that the error of constructing knowledge in geometry was caused by an error in the understanding of a geometric shapes.

Students who make mistakes just focus on geometric shapes with special names without learning the interrelationships of the geometric shapes in general. This can be seen when students are given a problem like in Figure 1. Students justify the picture is rectangular, because for them the side of the parallelogram should be tilted because they are accustomed to seeing parallelogram with sloping sides (Figure 3). This is because in recognizing students' geometry shapes, they are only focused on their form, not their analytic nature. Students actually have given reasons that the sides and angles facing each other, but the reasons stated were not able to change their understanding of parallelogram. They keep assuming that the image is not a parallelogram because it does not have slanted

Figure 1. The Problem Given in The Initial Research

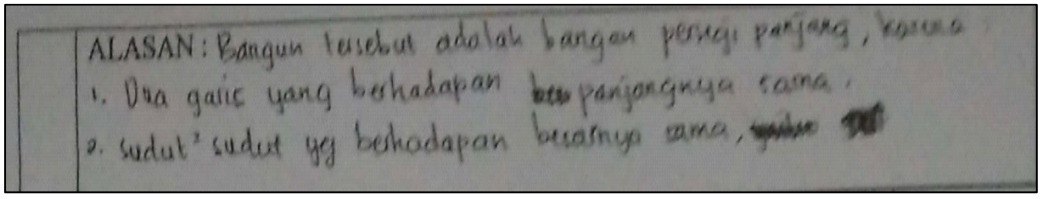

Figure 2. Reasons Given by Research Subjects

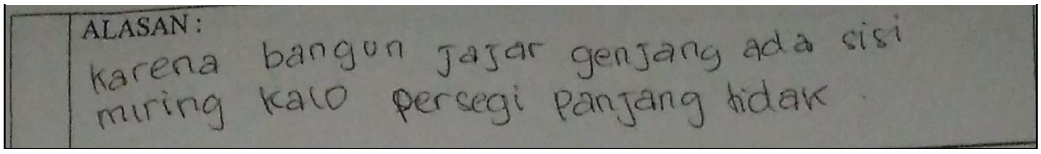

Figure 3. Reasons Given by Research Subjects

sides (Figure 2). Improper assimilation of the concept of geometric shape dominates students' thinking processes (Subanji, 2006). These mistakes may be a result of the learning experience of geometry at the previous level not referring to students' level of geometrical thinking. Therefore it is necessary to trace the level of thinking of students in geometry as a sign of appropriate geometric learning design. The level of geometry thinking for middle school students according to Eliyana (2016) should have reached level 2 (Abstraction), because they already have experience of learning geometry in elementary school.

Suwarsono (in Hadiyan, 2007) said that in developing deductive-axiomatic thinking skills, students' thinking abilities are crucial. Van Hiele leveled the thinking of geometry in five levels, namely; level 0: Visual, level 1 Analysis, level 2 Abstraction level, 3 Deduction, and level, 4 Accuracy.

To determine the level of students' geometry thinking, indicators are used (Hadiyan, 2007) which are described in the Table 1.

Researches on the level of geometry ability that have been done do not take into account the gender differences and only photograph the students without regard to their mathematical abilities. On the other hand, several research results conclude there are differences in visual-spatial and mathematical abilities between male and female students. Masriyah's research (Hadiyan, 2007), concluded that the verbal abilities of female students were higher than that of male students, while the visual-spatial abilities and mathematical abilities of male students were superior. This researcher focuses more on geometry material with the alleged geometric abilities of students between different men and women. In this study, researchers also suspect that mathematical thinking skills in male and female students are also different, based on indications on the results of the National Examination. In the Engineering Department with the majority of male students, the average National Examination scores are lower than students in the Department of Tourism and Business Management who are predominantly female students. These results indicate the need to consider gender aspects in studying the geometrical thinking skills of vocational students.

Based on the description above, this study aims to describe the level of geometrical thinking of SMK students in class XI based on Van Hiele's theory in terms of gender differences and mathematical abilities. By knowing the level of thinking of students 'geometry, learning scenario which is suitable and expected to improve students' geometry abilities can be made.

METHOD

The subject of this research was XI grade students of Computer Technology and Network of SMK Negeri 1 Grogol consisting of three male and three female students. The three students consisted of students with high, medium, and low mathematical abilities. This classification of mathematical abilities refers to the math scores of the previous semester. Firstly, the research subjects was given the Student Activity Sheet instrument. After the subject solved the problem, then they were interviewed. The interview was a structured interview. It focused on a deep exploration of drawing a quadrilateral, showing and defining a quadrilateral, grouping quadrilateral shapes, guessing the *mystery shape*, the equivalence of two definitions of the parallelogram, applying the principle of a quadrilateral.

Table 1. Indicator of Students Geometrical Thinking Level in Quadrilateral Learning

Thinking level	Indicator
0	1. Differentiating, identifying, and choosing geometric shapes using inappropriate properties 2. Defining geometry based on visual observations 3. Identifying quadrilateral shapes using irrelevant properties 4. Imagining the geometry drawn drawn is limited in number. 5. Choosing geometry with properties that are not in accordance with what has been mentioned. 6. Determining the geometry name does not refer to known properties.
1	1. Distinguishing geometry based only on the characteristics of its components. 2. Ignoring "class inclusions" (subsets) between rectangular buildings. 3. Classifying geometrical shapes is based only on the same properties 4. Determining the geometry of the mystery shape using only the properties that appear as necessary conditions. 5. Mentioning the nature not the name of the wake in describing a quadrilateral shape. 6. Defining quadrilateral based on the definitions in the book 7. Guided by drawing observations in testing the truth of a proposition or considering geometry as physics 8. Recognizing the geometrical properties of objects and presenting them on paper or in models.
2	1. Defining the complete geometry. 2. Defining quadrilateral with its own language, definitions of new concepts are able to be used 3. Mentioning the nature of the quadrilateral explicitly depends on the definition. 4. Understanding the equivalence of a definition. 5. Understanding "class inclusions" (subsets) between geometric shapes. 6. Selecting geometric shapes based on mathematical characteristics. 7. Using the implication statement appropriately. 8. Using the axioms and theorems appropriately. 9. Imagining the geometry that can be drawn infinitely many.
3	1. Clarifying questions or questions that have multiple meanings and formulating them in a more appropriate language. 2. Making guesses and be able to prove deductively 3. Deciding the value of the truth of a mathematical statement based on the available evidence. 4. Understanding the components in a mathematical material, for example axioms, definitions, and proof of a theorem. 5. Implicitly accepting Euclides' geometric postulates

Source : Hadiyan (2007)

RESULTS

The data analysis sequence for each ability level starts from the subjects with higher score (male subjects indicated by LT; female subjects indicated by PT). It was followed by the subjects with low score (male subjects indicated by LR; female subjects indicated by PR). The level of thinking of the subject was determined based on the indicators in the introduction.

Thinking Level Analysis of LT

The Figure 4 presents the quadrilateral shapes drew by LT. LT drew six quadrilateral shapes.

In comparing one quadrilateral shape with another shapes, LT refered to sides, alignment, diagonals, and the formula for area and perimeter. This can be seen from the following interview excerpt.

Q: How many different shapes can you draw?

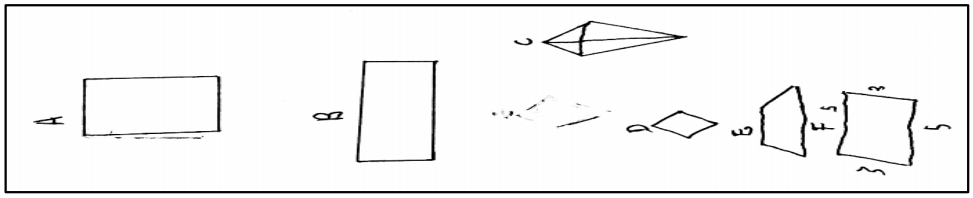

Figure 4. Quadrilateral Shapes Drew by LT

S: There are six shapes.
Q: Why are the rectangles different from each other?
S: Because they have different shapes and sides, some are parallel, some aren't and have different looking areas and perimeter.

The interviews above showed that LT was able to distinguish quadrilateral not only based on the sides but also the alignment and how to determine the area. But the LT did not know that the number of rectangles that can be made or the drawing was infinite. According to the indicator 4 from 0 thinking level and indicator 1 of thinking level 1, LT was categorized into thinking level 0 to 1.

Then, in showing quadrilateral shapes of LT was able to distinguish geometric shapes based on the properties of its components, but LT has not been able to see the *class inclusion* between quadrilateral shapes as shown in Figure 5.

In determining quadrilateral, LT composed the results in the Table 2. Table 2 describes improper properties of the components explained by LT in determining quadrilateral shapes. According to indicator 3 and indicator 1 of the level of thinking 1, it can be concluded that the level of thinking of LT is categorized into level 1.

In guessing mystery shape, LT required three directions in recognizing A shape as rhombus shape, three directions in recognizing B shape as trapezoid, three directions in recognizing as parallelogram, four directions in recognizing D as rectangle and five directions in recognizing E as kite. LT was able to recognize all shapes and utilized the provided informations. Thus, LT was categorized into level 1 of thinking according to 4.

In analysing the equivalency of two definitions of parallelogram, LT agreed that if a quadrilateral that each pair of opposite sides are parallel, then each pair of opposite sides are the same length. According to LT, the shapes were between rectangle and parallelogram. LT also agreed that if a square whose pairs of opposite sides are the same length, then each pair of opposite sides must be parallel. According to LT, the building that fulfills the above statement is a parallelogram. The above description shows that the LT did not yet know the equivalence of the two definitions of the parallelogram. According to indicator 7 and indicator 8 of the level of thinking 1, it can be concluded that LT is at the level 1 of thinking. The Figure 6 presents the Shapes According to the Miniature.

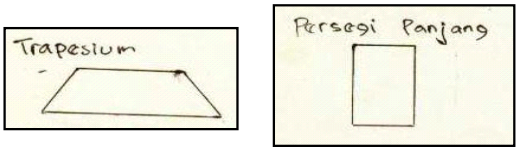

Figure 6. Shapes According to the Miniature

LT mentioned the geometrical properties of the miniatures which he has pointed out. This is evident in the following interview excerpt.

P: Try to mention the properties of a trapezoidal roof?
S: There is one pair of parallel sides.
P: Try to mention the properties of a rectangular window?
S: The sides that are facing the same length and are parallel.
P: Is there anything more like a quadrilateral?
S: Nothing.

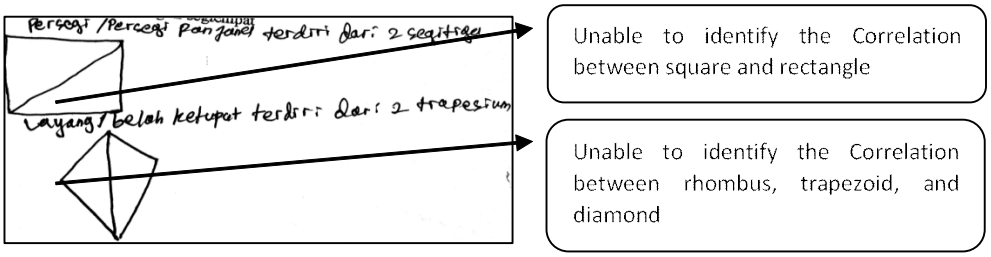

Figure 5. Quadrilateral Relationship Chart According to LT

Table 2. Shape Selection by LT

Order	No. The squares determined by students	Properties of squares (according to subject)
A.1	4, 6	The opposite sides are parallel
A.2	1, 8	All sides are the same length

Based on the description above LT fulfills the criteria on indicator 9 of the thinking level 1, but cannot meet the criteria on indicator 1 of the thinking level 3 and indicator 5 on the thinking level 2 it can be concluded that the LT students are at the thinking level 1.

From each activity carried out by LT, there are still some weaknesses, including the number of different quadrilateral shapes which were not to be understood by LT. Class inclusion, the equivalence of two definitions of parallelogram was not yet understood by LT. But LT analysis in classifying quadrilateral shapes based on the properties possessed by each shape has begun to appear. Thus, it can be concluded that the level of LT thinking is at the level of thinking 1 because it meets most of the thought level indicators 1 namely indicators 1, 2, 3, 4, 7, 8, 9 and does not meet any of the level of thinking indicators 2.

Thinking Level Analysis of PT

In drawing quadrilateral, PT was only able to draw six shapes. The Figure 7 presents the shapes drew by PT.

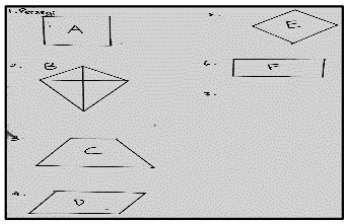

Figure 7. Quadriateral Shapes According to PT

In comparing a quadrilateral shape, PT refered to the side, the shape, and the different angle. This can be seen from the following interview excerpt.

P: How many different shapes can you draw?
S: six shapes
P: Are you sure there isn't anything else?
S: Sure
P: Why are they all different from each other?
S: Because of the different shapes and angles.

From the description above, it can be seen that there are only six shapes drew by PT. In distinguishing quadrilateral shapes, PT refered to the shape of a quadrilateral and its angle. Thus, it was concluded that PT was categorized into level 1 of thinking. PT's answers did not indicate the indicator 9 at level 2 because PT did not know that the number of rectangles that could be drawn was infinite.

In showing and defining a quadrilateral shape, PT made several mistakes, especially in the properties of each shape. These errors included mentioning a parallelogram having exactly a pair of angles facing equal and exactly a pair of sides parallel, rectangle having exactly a parallel pair of sides and exactly one diagonal dividing the two equal angles facing each other, the rhombus does not have the same side and the same length parallel sides and exactly the same pair of angles, square has exactly a pair of parallel sides and exactly the same pair of angles, and kite has equal facing angles.

In Figure 8, it shows that the PT remained ignoring the *class inclusion* of quadrilateral and made a mistake in explaining the relationship between parallelogram to a square and rectangular. According to the indicator 1 and indicator 2 at level 1 thinking, it can be concluded that PT was categorized into level 1. PT does not understand *class inclusion* so it does not meet the criteria of indicator 5 at level 2 thinking.

The Table 3 shows that in selecting a quadrilateral shape, PT defined improper properties and made

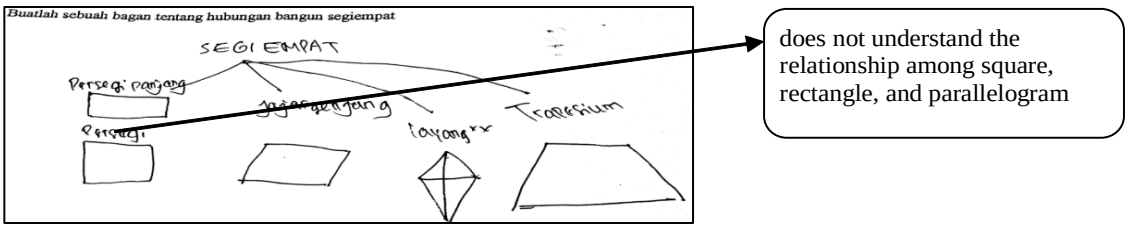

Figure 8. Quadrilateral Shapes Correlation made by PT

Table 3. Shapes Selection Made by PT

Order	No. The squares determined by students	Properties of squares (according to subject)
A.1	4, 2	Two pairs of sides with similar length
A.2	1, 8	Two pairs of sides with similar length

mistakes in selecting the same quadrilateral shape. In determining that the shape 4 was similar to shape 2, PT mentioned that both have two pairs of sides with the same length, whereas both shapes 4 and 2 are two different shpes although within inclusion class.

According to indicator 1 and 5 of the level of thinking 0, it can be concluded that the PT level of thinking is at the level 0.

PT requires three hints to guess A as a rhombus, three hints to guess B as a trapezoid, three hints to guess C as a parallelogram, three hints to guess wake D as a rectangle and need seven hints to guess wake E as rectangle kite. Based on the description above and guided by indicator 4 of the level of thinking 1, it can be concluded that PT is at level 1.

In identifying the equivalence of two definitions of parallelogram, PT agrees that if a quadrilateral each pair of opposite sides is parallel, then each pair of opposite sides is the same length. According to PT, the building in accordance with the statement above is a rectangle. PT also agreed that if a square whose pairs of opposite sides are the same length, then each pair of opposite sides must be parallel. According to PT, the building in accordance with the statement above is rectangular. PT stated that the two images he obtained were the same, namely rectangular. Based on the description above, it appears that PT still does not know the equivalence of the two definitions of parallelogram. According to indicator 7 and indicator 8 of the level of thinking 1, it can be concluded that PT is at the level of thinking 1.

In applying the quadrilateral concept in daily life, PT shows the miniature parts of a house in the form of a quadrilateral and the type of quadrilateral. The rectangular shaped parts are shown in Figure 9.

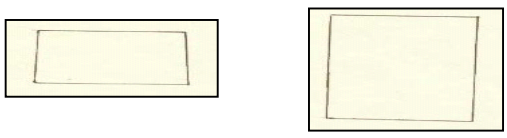

Figure 9. Image of Quadrilateral Shape According to Miniature

PT mentions the geometrical properties of the designated miniature. This can be seen in the following interview excerpt.

P: Try to mention the properties of square-shaped house windows?
S: All four corners are equal and all four corners are the same length.
……
P: Try to mention the properties of rectangular door?
S: The two pairs of sides that are facing the same length and the four right angles.
……
P: Is there anything more like a quadrilateral?
S: Nothing.

Thinking level of PT is at level 1 thinking because it meets most of the thinking level 1 indicators namely indicators 1, 2, 4, 7, 8, 9 and does not fulfill any of the level 2 thinking indicators.

Thinking Level Analysis of LS

LS can only draw six quadrilateral shapes. The six quadrilateral shapes are shown in Figure 10.

In comparing the differences in quadrilateral G

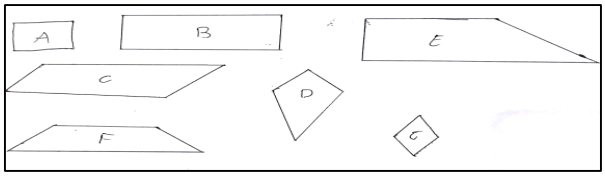

Figure 10. Quadrilateral Shapes According to LS

with other quadrilateral, LS was difficult in giving reasons, although LS wa able to make seven shapes.

Q: Why is the quadrilateral G different from the quadrilateral A, B, C, D, E, F?
S: I don't know
Q: Why are the rectangles different from each other?
S: Because of the large angles and the lengths of the different sides.

LS was able to distinguish quadrilateral based only on the side and angle attributes. Whereas LS did not know how many rectangles that can be made or drawn are infinity. Based on indicator 4 of the level of thinking 0 and indicator 1 of level 1 think, it can be concluded that LS students are between the level of thinking 0 and level of thinking 1. The LS does not meet the criteria of indicator 9 at the level of thinking 2 because LS do not know the many rectangles that can be made or drawn are infinity.

In showing and defining the quadrilateral, LS was able to mention the characteristics of a square, rectangular, parallelogram, rhombus, trapezoid and kite even though it remained imperfect. In addition, LS still ignored and did not understand the class inclusion of quadrilateral constructions. This can be seen from the picture drawn by LS (Figure 11).

Based on indicator 1 at the level of thinking 0, LS level of thinking is at the level of thinking 0. LS did not understand class inclusion so it does not meet the criteria of indicator 5 at level 2 thinking.

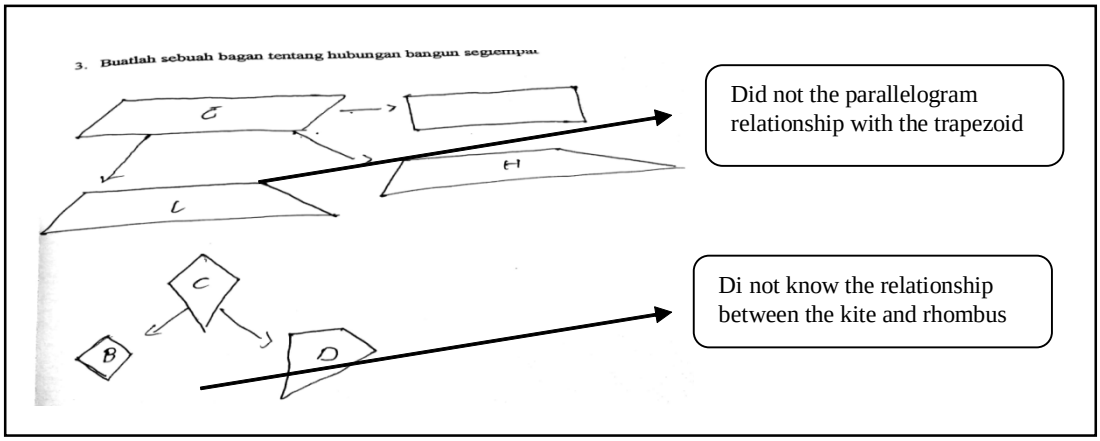

Figure 11. Quadrilateral Shapes Relationship Made by LS

In selecting quadrilateral shapes, LS took improper properties as presented in Table 4.

Table 4. Shape Slection Made by LS

Order	No. The squares determined by students	Properties of squares (according to subject)
A.1	1, 8	Having the same angle and the same length

Based on indicator 1 of thinking level 0 and indicator 3 of thinking level 1, it can be concluded that LS level of thinking is between level 0 and level 1 thinking.

LS cannot guess all shapes correctly despite repeated readings of the guide. Based on the description above and guided by indicator 6 of the 0 level of thinking, it can be concluded that the level of thinking LS is at the level of thinking 0.

In the equivalence activity, the two definitions of parrallelograms, LS agreed that if a quadrilateral with each pair of sides facing each other, then each pair of sides facing each other is the same length. According to LS, the shapes that meet the above statement is rectangular. LS also agreed that if a rectangle with each pair of opposite sides is the same length, then each pair of opposite sides must be parallel. LS stated that the two images he got were rectangles not parallelogram. Then it can be concluded that the LS does not know the equivalence of the two definitions of parallelogram. Based on the description above and guided by indicator 8 of the level of thinking 1, it can be concluded that the LS is at the level of thinking 1.

In the implementation of the quadrilateral concept in daily life, it can be seen that the parts of a miniature house in the form of a quadrilateral and the type of quadrilateral can be shown by the LS. LS mentioned the geometrical properties of the miniatures which he has pointed out. This can be seen in the following interview excerpt.

P: Try to mention the properties of a trapezoidal roof?
S: Has a pair of parallel sides.
……
P: Try to mention the properties of a rectangular window?
S: Has four pairs of sides that are equally large and has four equal angles.
……
P: Is there anything more like a quadrilateral?
S: Nothing.

Based on the description above, LS does not understand the equivalence of two parallelogram definitions. Thus, LS meets the criteria at indicator 9 of the thinking level 1, but cannot meet the criteria at indicator 1 of the thinking level 3 and indicator 5 at the thinking level 2. Then it can be concluded that LS students are at the level of thinking 1.

From the table above it is found that the level of thinking of LS students is more at the level of thinking 1, although in the second activity LS students are still at the level of thinking 0. This is possible students still do not understand the class inclusion of the quadrilateral shapes, besides that LS students also still don't understand about rotary symmetry and the many ways of a quadrilateral occupying the frame. So it can be concluded that the level of thinking of LS students is at the level of thinking 0 because most only meet the indicator level of thinking 0 even though it meets the indicator level of thinking 1 but it is not strong and tends to be at the level of thinking 0

Thinking Level Analysis of PS

LS could only draw three quadrilateral. The three quadrilateral drawings are shown in Figure 12.

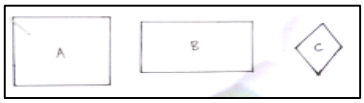

Figure 12. Quadrilateral Shapes According to PS

In comparing quadrilateral shapes, PS refered to the shape and side attributes. This can be seen from the interviewer (P) with the PS (S) students as follows.

Q: How many different shapes can you draw?
S: There are 3
P: Is that all?
S: Yes.
Q: Why are the rectangles different from each other?
S: Because, the size and symmetry of the folding and swivel are different.

From the description above, based on indicator 4 of the level of thinking 0 and indicator 1 of the level of thinking 1 it can be concluded that the PS is between the level of thinking 0 and the level of thinking 1. PS does not meet the criteria of indicator 9 at level 2 thinking because it does not know the number of quadrilateral which can be made or drawn is infinite.

Class inclusion of quadrilateral shapes was also still ignored by PS. This is seen when PS is asked to draw a quadrilateral relationship chart (Figure 13).

Based on indicators 1 and indicator 3 of the level of thinking 0 and indicator 7 at level 1 thinking, the level of PS thinking in this activity lies in the level of thinking 0-1. PS also do not understand class inclusion so it does not meet the criteria of indicator 5 at the thinking level 2.

In selecting rectangular shapes, students use the inappropriate properties seen in Table 5.

According to indicator 1 of the level of thinking 0 and indicator 3 of the level of thinking 1, it can be concluded that the PS level of thinking students is at level 0-1.

PS need three hints to guess A as a rhombus, could not guess B as a right trapezoid, need three hints to guess C as parallelogram, need three hints to guess D as a rectangle, need seven hints to guess E as a kite. Based on the description above and guided to indicator 4 of the thinking level 1, it can be concluded that PS is at level 1.

PS agreed that if a rectangle in which each pair of opposite sides are parallel, then each pair of opposite sides are the same length. According to students, the shape that meets the statement above is rectangular. Students also agree that if a rectangle with each pair of opposite sides is the same length, then each pair of opposite sides must be parallel. According to students, the shape that fulfills the statement above is square. PS stated that the two images obtained are not the same. Based on the description above, it appears that PS still does not know the equivalence of the two definitions of parallelogram by calling them two rectangular shapes. Guided by indicator 7 and indicator 8 of the level of thinking 1, it can be concluded that PS students are at the level of thinking 1.

In the application of the quadrilateral concept in daily life, it can be seen that the parts of the miniature house in the form of a rectangle and the type of quadrilateral can be shown by the PS. PS mentioned the geometrical properties of the miniatures which he has pointed out. This can be seen in the following interview excerpt.

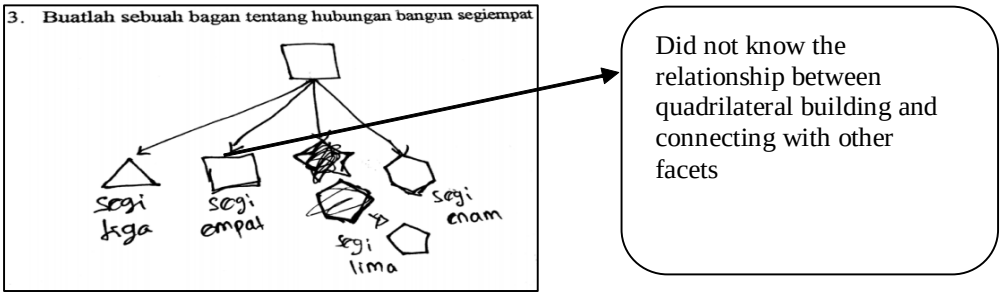

Figure 13. Quadrilateral Shapes Relationship Made by PS

Table 5. Shape Selection Made by PS

Order	No. The squares determined by students	Properties of squares (according to subject)
A.2	1, 8	Identical shapes and angles

P: Could you mention the properties of a trapezoidal roof?
S: The opposite sides are parallel.
P: Could you mention the properties of a square-shaped garage door?
S: All sides are the same length.
P: Is there anything more like a quadrilateral?
S: Nothing.

Based on the description above, PS meets the criteria on indicator 9 of the level of thinking 1, but cannot meet the criteria on indicator 1 of level 3 thinking and indicator 5 on the level of thinking 2. It can be concluded that PS is at the level of thinking 1.

From some of the activities above it can be seen that the level of PS thinking is more at the level of thinking 1, although in the second activity the PS is still at the level of thinking 0. So it can be concluded that the PS level of thinking lies at the level of thinking 1 because mostly PS have met the level of thinking 1: indicators 1, 3, 4, 7, 8, and 9.

Thinking Level Analysis of LR

LR could only draw six quadrilateral shapes. The shapes are shown in Figure 14.

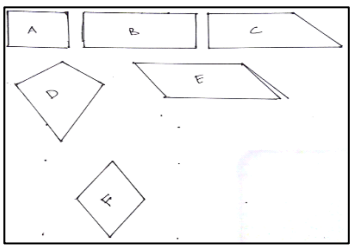

Figure 14. Quadrilateral Shapes According to LR

In comparing the quadrilateral, LR refered to the side and angle attributes. This can be seen from the interview excerpt with LR as follows.

Q: Why are the shapes different from each other?
S: Because the sides are not the same length and the angles are different.

From the description above it can be seen that LR can distinguish rectangles based only on the side and angle attributes, while LR did not know the number of rectangles that can be made or drawn is infinite. Based on indicator 1 and indicator 4 of the level of thinking 0, it can be concluded that LR is at the level of thinking 0. LR does not meet the criteria of indicator 9 at level 2 thinking because it does not know the number of rectangles that can be made or drawn is infinite.

The LR could show rectangular images provided but it still ignored the class inclusion of the rectangular shapes. This is also seen in the quadrilateral relationship picture according to LR (Figure 15).

LR did not understand class inclusion so it does not meet the criteria of indicator 5 at the level of thinking 2. Guided by indicator 3 of the level of thinking 0 and indicator 7 of the level of thinking 1, then the level of thinking of LR in this activity lies at the level of thinking 0-1.

In selecting quadrilateral, LR classified geometric shapes based on the similarity of two properties but could not select rectangular pairs that have other similarities. This can be seen in Table 6.

LR does not meet the criteria of indicator 6 at the thinking level 2 because LR could not select geometric shapes based on mathematical properties correctly and could not make conjectures, as well as trying to prove them deductively according to indicator 2 at the thought level 3. Based on indicator 3 of level 1 thinking, it can be concluded that LR level of thinking is at level 1.

LR required three hints to guess A as a rhombus, three hints to guess B as a right trapezoid, three hints to guess C as a parallelogram, three hints to guess D

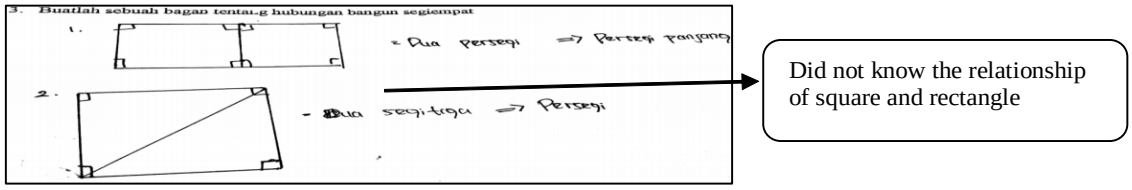

Figure 15. Quadrilateral Shapes Relationship made by LR

Table 6. Shape Selection Made by LR

Order	No. The squares determined by students	Properties of squares (according to subject)
A.1	1, 8	Two pairs of angles are equal and all sides are the same length

as a rectangle and five hints to guess wake up E as a kite. Based on the description above and guided by indicator 4 of level 1 thinking, it can be concluded LR is at level 1.

The LR in parallelogram alignment activities agrees that if a rectangle with each pair of opposite sides is parallel, then each pair of opposite sides is the same length. According to LR, the building that meets the above statement is rectangular. LR also agreed that if a rectangle with each pair of opposite sides is the same length, then each pair of opposite sides must be parallel. According to LR, the shape that fulfills the statement above is square. Based on the description above, it appears that LR still does not know about the equivalence of the two definitions of the parallelogram and the shapes are the same as rectangles. Guided by indicator 7 and indicator 8 of the level of thinking 1, it can be concluded LR students are at the level of thinking 1.

LR on the quadrilateral concept in daily life can be seen that the parts of a miniature house in the form of a quadrilateral and the type of quadrilateral can be shown by LR. LR mentions the geometrical properties of the miniatures which he has pointed out. This can be seen in the following interview excerpt.

Q: Could you mention the properties of a square window?
S: All sides are the same length, the diagonals are evenly split.
Q: Could you mention the properties of a rectangular window?
S: One pair facing each other (sides) is the same length, the diagonals meet exactly in the middle.

From the description above, it is found that the level of thinking of LR is at the level of thinking 1, although the LR students still do not quite understand about the properties of the trapezoid, which is precisely having one pair of sides that are parallel. So it can be concluded that the level of LR thinking is at the level of thinking 1 because it meets indicators 3, 4, 7, 8, and 9.

Thinking Level Analysis of PR

PR could only draw four shapes. The four shapes are shown in Figure 16.

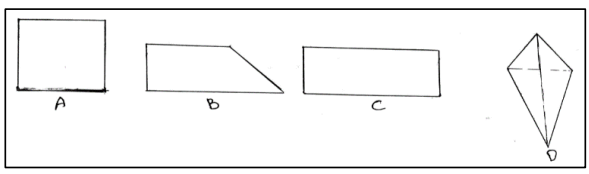

Figure 16. Quadrilateral Shapes Made by PR

In comparing quadrilateral, PR was comparing based on the attributes of sides, angles and diagonals, but PR could not mention why the rectangles made are different from each other. This can be seen from the interview excerpt as follows.

Q: How many different rectangular shapes can you draw?
S: There are 4.
Q: Why are the rectangles different from each other?
S: <silence>.

From the description above, it can be seen that PR cannot distinguish between the quadrilateral created, while the PR does not know the number of rectangles that can be made or drawn is infinite. Guided by indicator 4 of the level of thinking 0 can be concluded that PR level of thinking is at the level of thinking 0. PR does not meet the criteria of indicator 9 at level 2 thinking because PR does not know the number of rectangles that can be made or drawn is infinite.

PR could not show a square image, whereas PR was able to mention the characteristic square. PR ignorde the class inclusion of the quadrilateral shapes, this can be seen in the rectangular relationship drawings made by PR (Figure 17).

Guided by indicator 1 of thinking level 0 and indicator 7 of thinking level 1, then PR is at the level of thinking 0-1. In selecting quadrilateral shapes, PR used improper properties, as shown in Table 7.

PR does not meet the criteria of indicator 6 at level 2 thinking because PR could not select geometric shapes according to correct mathematical properties and could not make initial assumptions (conjecture), and try to prove them deductively according to indicator 2 at level 3 thinking. Guided by indicators 1 of the level of thinking 0, it can be concluded that PR level of thinking is at level 0.

PR required three hints to guess A as a rhombus, seven hints to guess B as a right trapezoid, three hints to guess C as a parallelogram, three hints to guess D as a rectangle and seven hints to guess E as a kite. Based on the description above and guided by indicator 4 of the level of thinking 1, it can be concluded that PR is at level 1.

PR agreed that if a rectangle with each pair of opposite sides is parallel, then each pair of opposite sides is the same length. According to PR, the shape that meets the statement above is square. The PR also agreed that if a square whose pairs of opposite sides are the same length, then each pair of opposite sides must be parallel. According to PR, the shape that fulfills the statement above is square. PR stated

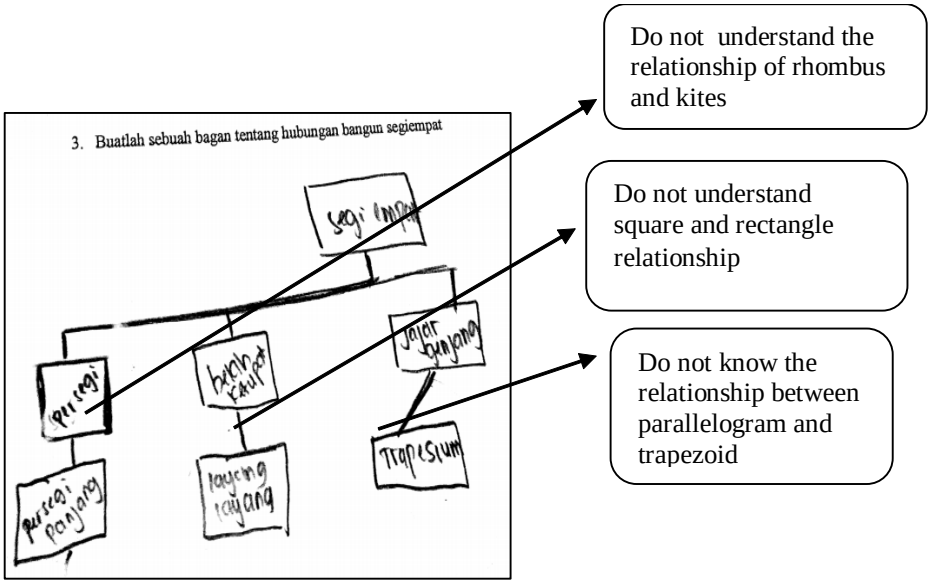

Figure 17. Quadrilateral Shapes Relationship by PR

Table 7. Shape Selection Made by PR

Order	No. The squares determined by students	Properties of squares (according to subject)
A.1	4, 6	Both have the same top bottom and left-right
A.2	7, 5	Both have irregular sides.

that the two images he obtained were the same. Based on the description above, it appears that PR still does not know about the equivalence of the two definitions of the parallelogram, even though it states that the structure is identical. Guided by indicator 7 and indicator 8 of the level of thinking 1, it can be concluded that PR is at the level 1 of thinking.

In applying the quadrilateral concept in daily life, it can be seen that the parts of a miniature house in the form of a quadrilateral and the type of quadrilateral could be shown by PR, but PR used improper properties. PR mentioned geometric properties from the miniatures that he has appointed. This can be seen in the following interview excerpt.

Q: Could you mention the properties of a trapezoidal roof?

S: The sides are not the same.

Based on the description above, PR meets the criteria on indicator 9 of the level of thinking 1, but can not meet the criteria on indicator 1 of the level of thinking 3 and indicator 5 on the level of thinking 2. It can be concluded that homework students are at the level of thinking 1 because PR meets the following indicators : 4, 7, 8, and 9.

From the description above, it is found that the level of thinking of PR is more at the level of thinking 1. From the results of interviews, it appears that PR still does not comprehend the quadrilateral shapes topic. This is seen when PR used improper properties the characteristics of the rectangular. PR does not really understand class inclusion from quadrilateral shapes. From the results of the analysis of each student's level of thinking, the level of thinking based on gender and group grades was obtained in the Table 8.

Table 8. Students' Level of Thinking Based on Gender

Male Students		Female Students	
Subject	**Level of Thinking**	**Subject**	**Level of Thinking**
LT	1	PT	1
LS	0	PS	1
LR	1	PR	1

From Table 8, it can be concluded that male and female students are at the same level of thinking. This is consistent with the opinion expressed by Cameron (in Hadiyan, 2007) stating that men's abilities are not different from women.

While differences in students' level of thinking when assessed from differences in mathematical abilities, can be seen in the Table 9.

From Table 9, it can be concluded that students who have high abilities and low abilities are at the same level of thinking. In contrast to students who have moderate abilities, there are still students who

Table 9. Student Thinking Level Based on Group Grades

High		Moderate		Low	
Subject	**Level of Thinking**	**Subject**	**Level of Thinking**	**Subject**	**Level of Thinking**
LT	1	LS	0	LR	1
PT	1	PS	1	PR	1

have a level of thinking 0. While the summary of the characteristics of the level of thinking that were exposed by each research subject, is presented in Table 10.

From the Table 10 it can be concluded that most students have weaknesses when distinguishing, identifying, and choosing geometric shapes still using improper properties. Students also still draw a limited number of shapes, whereas there should be many different shapes that can be drawn. Two subjects, namely PS and LS still use irrelevant properties in distinguishing geometrical shapes. All subjects in this study still ignored the class inclusion of rectangles and made mistakes when charting the relationships between rectangles. Students with high and medium ability were able to distinguish geometric shapes based on the properties of the components, and there was no student who stated that the number of shapes that can be drawn is infinite.

From the indicator at level 1 thinking that was fulfilled by all subjects except the LS in Table 10, it indicates that the lower the level of mathematical ability the less the indicator that is met even though it is at the same level of thinking.

Overall it appears that there is no striking difference between the level of thinking of male students with the level of thinking of female students: male and female students' level of thinking is at the level of thinking 1 (Analysis). Although there is male students (LS) who are still at the level of thinking 0. This is not contrary to the opinion of Cameron (in Hadiyan, 2007) which states that both male and female have no significance different.

In Table 4, the group of high grades and moderate grades had no difference in the level of thinking, but in the moderate grads group there were still students who were at the level of thinking 0, it was LS. This is possible because the student's intellectual abilities was lacking or when receiving quadrilateral topic in class students paid less attention to the teacher. Thus, during the interview, student had a very limited answer.

The level of thinking of all research subjects except LS are at the level of thinking 1 (Analysis). This is not in accordance with the ideal conditions of the level of thinking of Middle School students who are at the level of thinking 2 (Abstraction) as expressed by (Eliyana, 2016)). Possibly, vocational school children, especially in the KTSP curriculum (Education Unit Level Curriculum) are given different curriculum targets with high school despite having different stages of age and cognitive development. In the vocational high school curriculum, it is more focused on the work preparation and thus the normative subjects (subjects other than productive) is less given. Students tend to focus on productive subjects. In addition, students are not at the level of ideal thinking because learning geometry material has not been referring to the level of students thinking geometry. The teacher does not know the level of thinking of students who will be given geometry learning material and tends to assume all students are at the same level of thinking.

DISCUSSION

From the results of data analysis, it is generally seen that the level of thinking of research subjects is at level 1 (analysis) and only one student is at the level of thinking 0 (visualization) on quadrilateral topic. This means that the research subjects have not reached the level of thinking 2 (abstraction) as expressed by van Hiele. Van Hiele said that thinking level 2 was the ideal level of thinking that Middle School students must have. So it can be said that students who are at the level of thinking 0 are only able

Table 10. Summary of Students' Thinking Levels

	Indicators			
	Level 0	**Level 1**	**Level 2**	**Level 3**
LT	4	1, 2, 3, 4, 7, 8, 9	-	-
PT	1, 5	1, 2, 4, 7, 8, 9	-	-
LS	1, 4, 6	1, 3,7, 8, 9	-	-
PS	1, 3, 4	1, 3, 4, 7, 8, 9	-	-
LR	1, 3, 4	3, 4, 7, 8, 9	-	-
PR	1, 4	4, 7, 8, 9	-	-

to recognize quadrilateral shapes based on visual considerations. Students still used improper properties to distinguish, identify, and choose geometric shapes. While research subjects who are at the level of thinking 1, have begun to pay attention to parts of quadrilateral shapes, such as their sides and angles. Students have started to be able to use the right properties in distinguishing, identifying, and choosing geometric shapes, although there was student who used properties that are not relevant in mentioning the nature of quadrilateral shapes.

Another interesting finding is that students still do not understand class inclusion, although assistance has been given in the form of quadrilateral properties table. In addition, there are still many students who still cannot imagine that there are infinite numbers of different rectangles that can be drawn. This is in line with (Santia, 2015) which reveals students are still having difficulty in arranging quadrilateral relationships among 15 quadrilateral relationships because they only pay attention to one element in quadrilateral drawing and drawing activities, namely the shape of a drawing.

From the results of data analysis summarized in, overall it appears that there is no striking difference between the level of thinking of male students with the level of thinking of female students, namely male and female students' level of thinking is at level 1 thinking (Analysis). Even though there are male students (LS) who are still at the level of thinking 0. This is in accordance with the opinion expressed by Cameron (Hadiyan, 2007) which states that there is no difference between male and female abilities. Differences in the visual-spatial abilities of male and female students as revealed by Masriyah (Hadiyan, 2007) also did not appear in this study. It is seen that male and female students have the same level of geometrical thinking. Another case with the difference in the ability to think based on value groups. In Table 9, the high scores and low scores groups did not have different levels of thinking, but in the moderate grades groups there were students who were at the level of thinking 0, namely LS students. This is possible because the students' own intellectual abilities are lacking or when receiving quadrilateral material in class students pay less attention to their teacher, so the time of interviewing students is less precise in answering. This is also in accordance with research (Zhumi, 2013) on junior high school students who state that in one class even though the material given geometry is the same and with the level of mathematical ability of students who are relatively the same but have different levels of geometrical thinking.

The level of thinking of all research subjects except LS is at the level of thinking 1 (Analysis) This is not in accordance with the ideal conditions of the level of thinking of Middle School students who are at the level of thinking 2 (Abstraction) as expressed Eliyana (2016)) in his research. Some other studies relating to the level of thinking of high school students' geometry include: Mairing (2016) also describes the geometrical abilities of VII grade junior high school students from one of the schools in the city of Palangka Raya based on Van Hiele's theory. The results showed that 97.2% of students had level 0 skills and 2.8% of students had level 1. Musa (2014) revealed that junior high school students' level of thinking was between the level of thinking 1 and 2. Nafiah (2017) in his research on VII-1 grade students of SMPN 1 Prambon Nganjuk revealed that the achievement of male and female subjects was the same based on Van Hiele's theory, namely in stages 1, 2, and 4. This was made possible by the average of vocational school children especially in the KTSP curriculum (Education Unit Level Curriculum) is given different curriculum targets with high school level children despite having different stages of age and cognitive development. In the SMK curriculum is more focused on the target curriculum ready for work so that the curriculum burden on normative subjects (subjects other than productive) is less. Students tend to focus on productive subject matter. Another thing that is a probable cause, students are not at the level of ideal thinking because learning geometry material has not been referring to the level of students thinking geometry. The teacher does not know the level of thinking of students who will be given geometry learning material and tends to assume all students are at the same level of thinking.

From the indicator at level 1 thinking that was fulfilled by all subjects except male students with moderate ability in Table 10 had a pattern of lower levels of mathematical ability, the indicator that was fulfilled even though it was at the same level of thinking. This is possible because students have different geometrical learning experiences prior to being interviewed even though they are broadly speaking at the same level of thinking.

CONCLUSION

From the analysis of the data it was concluded that students with high abilities were at the level of thinking 1 (Analysis). Students with moderate ability

are at the level of thinking 0 (Visual) while PS is at level 1 (Analysis). Students with low ability are at the level of thinking 1 (Analysis). It is seen that there is no striking difference between the level of thinking of male and female students. However, according to students' mathematical abilities, the level is different. High and low grades group students are are at level 1 thinking, whereas in the moderate group only one student (PS) is at level 1 thinking and the others are at level 0 thinking.

All subjects are at the level of thinking 1 (Analysis), except male student with moderate mathematical abilities, the lower the level of mathematical ability the less the number of indicators are met even though at the same level of thinking.

Some suggestions that can be raised include: in teaching geometry topic, the teacher should pay attention to the student's level of thinking. Because if students are taught on a topic above the level of thinking, students will have difficulty in understanding the topic. If the teacher wants to teach geometry by classifying students homogeneously, grouping students according to their level of thinking, then the teacher should be able to distribute teaching time appropriately, thus the objectives of learning are achieved. This research only portrays the level of thinking of vocational schools, it is hoped that in future research models of learning that can be developed in accordance with the level of geometrical thinking of vocational students that have been analyzed.

REFERENCES

Eliyana, Y. (2016). *Penerapan teori Van Hiele pada materi geometri dimensi tiga dalam menganalisis kesulitan belajar siswa* (Unpublished master's thesis). Universitas Ar-Raniry Banda Aceh, Indonesia.

Hadiyan, A. (2007). *Penelusuran tingkat berpikir geometri siswa laki-laki dan perempuan SMP Negeri I Kraksaan Probolinggo berdasarkan teori van Hiele* (Unpublished master's thesis). Universitas Negeri Surabaya, Indonesia.

Hartanto, S. dkk. (2015). Komparasi pemahaman geometris karyawan lulusan SMK dan SMA terhadap proses machining CNC di PT. Tomoe Valve Batam Suryo. *Pythagoras*, *4*(2), 34–42.

Hidayati, D. W. (2017). Penerapan problem based learning berbasis self-directed learning oriented assessment terhadap kemampuan pemecahan masalah. *Journal of Medives: Journal of Mathematics Education IKIP Veteran Semarang*, *1*(1), 17–24.

Karimah, S. (2013). Pembelajaran kooperatif tipe STAD (Student Team Achievement Division) dalam meningkatkan aktivitas dan hasil belajar. *Delta Jurnal Ilmiah Pendidikan Matematika FKIP Universitas Pekalongan, 1*(1).

Mairing, J. P. (2016). Tingkat berpikir geometri siswa kelas VII SMP berdasarkan teori Van Hiele. *Aksioma, 5*(1).

Musa, L. A. D. (2014). Deskripsi level berpikir geometri menurut teori Van Hiele berdasarkan kemampuan geometri dan perbedaan gender pada siswa kelas VII SMP Negeri 8 Parepare. *Jurnal Pendidikan Matematika dan Ilmu Pengetahuan Alam*, *4*(2), 103–116.

Nafiah, M. N. (2017). Identifikasi tahap pemahaman geometri siswa berdasarkan teori Van Hiele ditinjau dari perbedaan gender pada materi persegipanjang kelas VII SMP. *MATHEdunesa*, *6*(2).

Nurjannah dkk. (2017). Design and development computer-based e-learning teaching material for improving mathematical understanding ability and spatial sense of junior high school students. *Journal of Physiscs:Conference Series*, *812*. https://doi.org/10.1088/1742-6596/755/1/011001

Rahayu, S. (2016). Analisis kesalahan siswa dalam menyelesaikan soal-soal aljabar berdasarkan gender. *Jurnal E-DuMath*, *2*(1), 347–354.

Santia, I. (2015). Cara berpikir geometris siswa dalam menentukan hubungan. *Jurnal Math Educator Nusantara*, *1*(3), 145–158.

Subanji, S. (2006). Berpikir pseudo penalaran kovariasi dalam mengkonstruksi grafik fungsi kejadian dinamik: Sebuah analisis berdasarkan kerangka kerja VL2P dan implikasinya pada pembelajaran Matematika. *Jurnal Ilmu Pendidikan*, *13*(1), 1–8. https://doi.org/10.17977/jip.v13i1.57

Suryantono, B. (2013). Peningkatan hasil belajar geometri melalui pembelajaran pemecahan masalah. Jurnal pendidikan. *Lentera Jurnal Kependidikan*, *12*(1), 91–100.

Zhumi, A. I. (2013). Pengaruh tingkat berpikir geometri (teori Van Hiele) terhadap kemampuan berpikir siswa dalam mengerjakan soal pada materi garis dan sudut. *Jurnal EDUMA*, *2*(2).