Analyzing the student's cognitive abilities through the thinking levels of geometry van hiele reviewed from gender perspective

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Abstract. The process of thinking of students in understanding concepts and solving problems about geometry influenced by the cognitive ability of the level of geometry thinking of students, whether male or female. Van Hiele explained that there are five levels of thinking geometry. This study was conducted to determine the cognitive abilities of junior high school students based on Van Hiele's geometry thinking level viewed from a gender perspective. The method used is a descriptive qualitative method with question instruments and interview guidelines. The research subjects were six female students and six male students. The results of tests and interviews were analysed to determine the level of the tendency of students' geometric thinking. Research results show that there are four male students at level 3 (Deduction) and two students at level 2 (Informal Deduction). Whereas for female students there were three students at level 3 (deduction), two students at level 2 (simple deduction) and one student at level 1 (analysis). Male students are better at visual abilities and prefer simple ways of writing answers, while female students are better at verbal abilities and neater in writing answers. So it can be stated that male students tend to be superior to female students. This can be the basis for the treatment of students based on gender and cognitive abilities of students' level of geometry thinking.

1. Introduction
Mathematics is a tool to train the thinking process. It is also essential to deal with the progress of science and technology[1–3]. Mathematics as a basic science plays a vital role in the development of science and technology because it is a means of thinking to develop the power of reasoning, logical, systematic and critical thinking [4,5]. Cognitive is a thinking process that includes memory abilities, understanding, application, analysis, evaluation and creating [3,6–8] .Anderson revealed that 7 cognitive processes occur when someone understands a concept, namely: interpreting, exemplifying, classifying, summarising, influencing, comparing, and explaining [9].

Cognitive ability is one of the domains that becomes the most important assessment in the learning process[7]. So from that cognitive domain must get more attention from each teacher[10]. Every individual has different cognitive abilities. The diversity of students' cognitive abilities needs to reviewed from a gender perspective so that the results will be far more effective. In teaching and learning activities the teacher must follow the way of thinking of students both male and female.
Differences in gender will cause different thinking tendencies [10,11]. Gender is the nature and behaviour inherent in men and women that are formed socially and culturally [12]. Gender differences are one of the factors that influence differences in students' cognitive abilities. That is because men and women have different behaviours and habits that cause differences in their abilities. Students' ability to understand the material conveyed by the teacher will also be more diver[7].

Halpern states that there are abstract abilities and to process information accurately and quickly and that we examine performance on complex tasks, meaningful, separable factors emerge [13]. That becomes a problem for every teacher. Often the teacher carries out learning activities without first knowing the characteristics and knowing the abilities of each student. So that there is no synchronisation of thought processes between teachers and students. A good teacher must always pay attention to the development of students' abilities [10,11,14]. The weakness of a teacher is ignorance of the cognitive abilities of each student. So that students have difficulty understanding the material. The weakness of students in analysing questions, monitoring the process of completion and evaluating the final results in students lacking skill in solving problems given [15]. This causes student’s inability to learning objectives and student learning outcomes that are not good. If it is not quickly followed up, then the student learning process will be hampered. So that there are still many teachers who apply conventional mathematics learning such as teacher-centred, teachers explain mathematics through lecture methods, passive students, questions from students rarely appear, oriented to one correct answer, and class activities that done is simply recording or copying [16] It will not develop students' cognitive abilities.

Cognitive ability used as a measure of the success of a learning process [9]. Cognitive ability is supported by understanding concepts and solving ethical problems by students. It obtained if the creation of an effective learning process in the classroom. In solving geometry problems, thinking patterns needed in applying geometric concepts and skills [17]. Therefore, students need problem-solving skills that are sufficient so that it said that students are familiar with mathematical concepts [18]. Especially in mathematical geometry. Geometry used by everyone in everyday life and occupies a unique position in the mathematics curriculum, because of the many concepts contained in it [19]. According to Hoffer geometry is inherent in visual skills, verbal skills, drawing skills, logic skills and applied skills [10,11]. Maccoby & Jacklyn said that women have verbal abilities that are better than men while men are superior in visual abilities [12]. Based on the five types of geometry skills, the geometrical abilities referred to in this study are the ability to observe objects, build definitions based on characteristics on objects, recognise relationships between objects with other objects, and apply them to geometry problem-solving. It also needs to be reviewed from a gender perspective so that the results will be far more effective.

Because gender differences will cause different thinking tendencies [11]. Previous research states that male students categorized as superior in critical thinking to solve mathematical problems compared to the rest of women [14]. Van Hielen noted that there are five levels of geometrical reasoning, namely: level 0 (Visualization), level 1 (Analysis), level 2 (Informal Deduction), level 3 (Deduction), and level 4 (Rigor) [8,11,17,19,20]. At the visualisation level, students recognise geometrical forms of visual characteristics and appearance but have not been able to understand and determine the geometry and the building characteristics shown. At the level of analysis, students can learn the properties of a construct by observing, measuring, experimenting, drawing, and modelling but cannot see the building between several geometric shapes.

At the Informal Deduction level, students can already know the relationship that related between a geometrical construct and other geometry. At this stage, students have understood the order of geometric structures. At the Deduction level, students can compile evidence, not just accept evidence and have assumed the vital role of elements that are not defined, in addition to the features that are identified. However, students do not understand the usefulness of a deductive system. At Rigor level students reason formally in a mathematical operation and can analyse the consequences of axiom manipulations and definitions [17]. Weak students in examining the questions, monitoring the completion process and evaluating the final results lead to less skilled students in solving the problems.
given[15]. Mathematics as a basic science plays a vital role in the development of science and technology because it means thinking to develop the power of reasoning, ways of thinking logically, systematically, and critically[4]. Here are Van Hiele geometry thinking level indicators:

| LEVEL | CHARACTERISTICS | INDICATOR |
|-------|----------------|-----------|
| 0 (Visualization) | Students recognise geometric forms of visual characteristics and appearance but have not been able to understand and determine the geometrical properties and the building characteristics shown. | 1. Identify the build based on the form it sees in its entirety.  
2. Determine the example and which is not an example of drawing geometry. |
| 1 (Analysis) | Students can determine the properties of a construct by observing, measuring, experimenting, drawing, and modelling but have not been able to see a building between several geometrical builds. | 1. Describe awake based on its properties.  
2. Comparing wake-up based on its properties.  
3. Conduct problem solving involving recognisable build properties. |
| 2 (Informal deduction) | Students have been able to know the relationship that related between a geometrical construct and other geometry. Students who are at this stage already understand the ordering of geometrical structures. | 1. Compile a definition of a build based on the properties between geometry builds.  
2. Explaining the relationships related to geometry, although not yet at a formal level based on the information provided.  
3. Explain the relationships related to geometry, although not yet at a formal level based on the information provided. |
| 3 (Deduction) | Students can compile evidence, not just accept evidence and have understood the importance of the roles that are not defined, in addition to the elements identified. However, students do not understand the usefulness of a deductive system. | 1. Understanding some mathematical statements such as axioms, definitions and theorems.  
2. Compile the evidence deductively |

Source: Musa[11]

Because each level has different characteristics, then from the Table 1 it can be seen that a student is stated to be at a certain level when students have reached the geometry thinking level indicators according to the relevant standard.

2. Method
This research uses the qualitative descriptive method with question instruments and interviews based on Van Hiele's thinking level. Instruments are arranged based on Van Hiele's geometrical thinking level indicators and validated by several experts in their fields. The researcher analysed the mathematical value of the student report card to determine the subject of the study. Topics are selected based on the highest score and gender so that the expected level of students' geometry thinking can
identified. Subjects in this study were six male students and six female students in class VIII of Cirebon City 6 Middle School 2017/2018 Academic Year. Subjects given tests and interviews that had adjusted with Van Hiele geometry thinking level indicators. The conclusions drawn from the answers to the tests and the results of the interviews that have been carried out to the Subject based on Van Hiele geometry level indicators. So that the level of cognitive ability of students' geometry thinking level identified.

3. Results and Discussion
A study was conducted to answer a problem by providing a conclusion at the end of the study. To get a conclusion, a test is performed using a series of research instruments. In this case, the instrument used is a description problem based on the level of Van Hiele's geometry thinking. Then the results of the test answers for each subject are analysed to get a conclusion. The following are the test questions given to the research subjects:

| No | Question |
|----|----------|
| 1  | Pay attention to the following picture! |
|    | (a) ![Image](a.png) (b) ![Image](b.png) (c) ![Image](c.png) (d) ![Image](d.png) (e) ![Image](e.png) (f) ![Image](f.png) |
|    | a. Explain with your thoughts, how the shape of each one builds the space above! |
|    | b. Determine which one is the prism space? What is your reason? |
| 2  | Pay attention to the following picture! |
|    | (a) ![Image](a.png) (b) ![Image](b.png) (c) ![Image](c.png) (d) ![Image](d.png) |
|    | a. Explain the properties that have built up space above! Express it in your language! |
|    | b. What is the difference from all of the above spaces? What can you conclude? |
|    | c. What type of wake found in the picture above? |
|    | d. If water filled into the building space above, which one can hold the most water? If you know, all the ribs are 2 cm long, and the ribs are 4 cm long. (Area of triangle = \( \frac{1}{2} s^2 \sqrt{3} \). Area of rectangle = \( s^2 \). Area of pentagon = 1.72 x \( s^2 \). Area of hexagon = 2.598 x \( s^2 \). with \( s \) = length the rib.) |
| 3  | Explain the difference between cubes and beams based on their properties! |
| 4  | Can you distinguish between diagonal fields and diagonal spaces? Draw the ABCD cube first. EFGH! |
| 5  | If \( s \) is the length of a cube, prove that the diagonal of a cube is \( s\sqrt{2} \) cm! use the pythagoras formula to prove it. |
| 6  | The volume of any pyramid is a third the height of the base. Prove the theorem which states the volume of any pyramid! |

Table 2 states that the question consists of 6 questions about the primary subject matter of building a flat side space which is arranged based on Van Hiele geometry thinking level indicators to determine
the tendency of students' level of thinking. After the subject given a test and interview, the results of the direct answer are analysed based on Van Hiele's level of geometrical thinking indicators, and each subject is given the respective subject code to facilitate the exposure of the data.

The following is the analysis of the cognitive abilities of male and female students based on Van Hiele's geometry thinking level on the answer sheet and the interview results of each subject:

Table 3. Thinking Levels of Male Student and Female Student Each Question Item

| Subject | Level 0 | Level 1 | Level 2 | Level 3 | Result Level |
|---------|---------|---------|---------|---------|--------------|
|         | 1       | 2       | 3       | 4       | 5       | 6       |
| SL1     | O       | O       | O       | O       | O       | O       | X       | 3       |
| SL2     | O       | O       | O       | O       | O       | O       | X       | X       | 2       |
| SL3     | O       | O       | O       | O       | O       | O       | X       | X       | 2       |
| SL4     | O       | O       | O       | O       | O       | O       | X       | 3       |
| SL5     | O       | O       | O       | O       | O       | O       | X       | 3       |
| SL6     | O       | O       | O       | O       | O       | O       | X       | 3       |
| SP1     | O       | O       | O       | O       | O       | X       | X       | X       | 2       |
| SP2     | O       | O       | O       | O       | O       | O       | X       | 3       |
| SP3     | O       | O       | O       | O       | O       | O       | X       | 3       |
| SP4     | O       | O       | O       | O       | X       | X       | X       | 1       |
| SP5     | O       | O       | O       | O       | O       | O       | O       | X       | 3       |
| SP6     | O       | O       | O       | O       | O       | X       | X       | X       | 2       |

Information:

O : Reached
X : Not achieved

From Table 3, it can be seen that there are different levels of thinking between male and female students. Male and female subjects tend to be at level 3 (deduction), i.e. students have been able to compile evidence, not just accept evidence and have understood the importance of the role of elements that are not defined, in addition to the features identified. However, students do not understand the usefulness of a deductive system.

Of the six male students obtained four students at level 3 (deduction) and two students at level 2 (simple inference). Subjects of SL1, SL4, SL5, and SL6 can reach level 3 indicator one which is understanding some mathematical statements such as axioms, definitions and theorems. However, the subject has not yet reached indicator 2 level 3, which is compiling the evidence deductively. Even so, students are considered capable of collecting evidence, not just receiving indication and having understood the vital role of elements that are not defined, in addition to the features identified. However, students do not understand the usefulness of a deductive system. The subjects of SL2 and SL3 are only able to reach level 2 indicator 2, which is to explain the relationships related to geometry, although not yet at a formal level based on the information provided. Thus the two students have been able to know the link related between a geometrical construct and other geometry. Students at this stage have understood the ordering of geometrical structures.

Of the six female students, there were three students at level 3 (deduction) 2 students at level 2 (simple inference) and one student at level 1 (analysis). Subjects of SP2, SP3 and SP5 have been able to reach indicator one at level 3 (Deduction) which is understanding several mathematical statements such as axioms, definitions and theorems. Subjects have not yet reached indicator 2 level 3 which is compiling deductive evidence. Even so, students are considered capable of collecting evidence, not just receiving indication and having understood the vital role of elements that are not defined, in addition to the features identified. However, students do not understand the usefulness of a deductive system. SP1 and SP6 subjects have been able to reach indicator two at level 2, which is to explain the
relationships related to geometry, although not at the formal level based on the information provided. Then the student is considered to be able to know the link related between a geometrical wake and other geometry. Students who are at this stage already understand the ordering of geometrical structures. SP4 subjects can reach the indicator 2 level 1 which is comparing the builds based on their properties. Students have not yet reached indicator 3 level 1, which is to solve problems that involve recognisable traits. Even so, students are considered able to determine the properties of a building by observing, measuring, experimenting, drawing, and modelling but have not been able to see the building between several geometrical builds. These results prove that cognitive abilities based on Van Hiele's geometrical thinking level of men tend to be superior to women. In analysing students' answers, researchers also found several differences between male and female students as shown below:

| No | Male Student                                    | Female Student                      |
|----|-------------------------------------------------|-------------------------------------|
| 1  | Superior in visualisation skills                | Superior in Verbal ability          |
| 2  | Short and straightforward in answering questions | Neat in writing answers             |

From the Table 4 it is seen that both have their advantages. Men are considered better in the ability to visualise while women are better at communication skills. Differences are also found in the subject of writing; women are neater in writing answers while men prefer short and simple ways to answer questions.

The following are some examples of differences between men and women during the research process:

**Table 5. Answer Problem No. 1a**

| Male Student                                                                 | Female Student                                                                 |
|-----------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| 1. *Kdeku = *kotak.                                                        | *Kdeku = *kotak.                                                            |
| *Kedok = * * Penata yang berhadapan.                                          | *Kedok = * * Penata yang berhadapan.                                          |
| *Prisma = * * * Penata yang berhadapan.                                      | *Prisma = * * * Penata yang berhadapan.                                      |
| *Limas = * * * Penata yang berhadapan.                                       | *Limas = * * * Penata yang berhadapan.                                       |
| *Limas = * * * Penata yang berhadapan.                                       | *Limas = * * * Penata yang berhadapan.                                       |
| *Limas = * * * Penata yang berhadapan.                                       | *Limas = * * * Penata yang berhadapan.                                       |
| *Kotak = * * * Penata yang berhadapan.                                       | *Kotak = * * * Penata yang berhadapan.                                       |

From Table 5 it can be seen that male students are superior in identifying the shape of space, in this case, the visual abilities of students. Visual flair is the ability to recognise various types of flat
building and area, observe the parts of a building and the connection of one piece to another, classify geometric constructs according to observed characteristics, conclude advanced information based on visual observations[21]. Male students are more detailed in explaining the shape of each space given to the problem. The male student's perspective is broader. But in writing female students’ answers more neat, so that the reader is easier to read the responses. So in writing skills, female students are considered superior to male students.

Table 6. Answer Problem No. 2c

| Male Student | Female Student |
|--------------|----------------|
| ![Diagram](image) | ![Diagram](image) |

In Table 6, it seen that in writing answers, male students are more straightforward and shorter than what female students do in writing their answers. With writing like that, men try to show that in general, all building space is a type of colorful space. Among them are a quadrilateral prism, triangular prism, hexagonal prism and pentagonal prism. While the way of writing answers to female students shows more detailed and communicative. It also shows that female students have more ability in students' verbal skills. Verbal ability is the ability to display various geometrical constructs by name, visualise geometry wake up according to its verbal description, specific geometry and its properties, formulate definitions correctly and correctly, express inter-wake relationships, recognise logical structures of oral problems, and formulate generalisation statements and abstraction[21].

4. Conclusion
The study concluded that there were differences in the cognitive abilities of junior high school students based on Van Hiele's geometrical thinking level on the topic of building a flat green side space from a gender perspective. In male students, there are four students at level 3 (deduction) and two students at level 2 (simple inference). In female students, there are three students at level 3 (inference), two students at level 2 (simple inference) and one student at level 1 (analysis). The highest level of both is at level 3 (inference). Based on the results of the study it can be stated that male students tend to be superior to female students. Male students are superior to visual abilities and prefer simple ways of writing answers, while female students are more superior to verbal skills and neater in writing answers.

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