The van hiele levels of geometric of students in first semester reviewed from gender

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Abstract. This research is an exploratory study that aims to examine the geometry abilities of students based on gender. Participants numbered 90 people. The number of female students is 72 people and male students are 18 people. Participants are students of biology education programs who attend basic mathematics lectures in the first semester at one of the universities in Indonesia. The instrument of the geometry thinking level used test from CDASSG project. The results showed that from 18 male students as many as 4 people were at the level of pre-visualization, 2 were at level 0, and 12 were at level 1. Whereas of 72 female students, 13 were at pre-visualization level, 21 were at level 0, 34 people are at level 1, and 4 people at level 2. Based on these results there is a difference between male and female students, namely some female students reach level 2, but not male students.

1. Introduction
Geometry is one of the important concepts studied by students. Geometry is important because it plays a role in the concepts of astronomy, chemistry, biology, algebra, statistics, calculus [1]. Bobango claimed that the aim of geometry learning is so that learners have belief in mathematical competence, can communicate, become great problem solvers, and have mathematical proficiencies [2].

Van Hiele stated that one's ability to work in geometry is affected by one's geometry learning experiences [3]. Lecturer must know the level of development of his student thinking. Because if his knowledge is different from students, the lecturer's explanation is not understood by students (P M van Hiele) [4]. So that the teacher needs to identify the geometry level of the student. Research of geometric level was carried out by PM van Hiele and research about geometry learning was carried out by Dina van Hiele-Geldof in 1957. Research on van Hiele's theory has been done by many others and the implications of van Hiele's theory for curriculum, teacher education, and classroom practice [5].

Keitel stated that one of the factors that influence mathematics learning is gender [6]. Gender here is the sex of students. Gender differences certainly cause differences in physiology and affect psychological differences in learning, so that male and female students certainly have many differences in mathematics learning [6]. Gender inequality at the university level has been a serious phenomenon for some time [7]. So, the lecturer must pay attention to gender in the learning process. The results of Musdalifah et al. research recommend that teachers better understand the character between men and women [8].
Self efficacy is also an important. Self efficacy refers to the ability to organize and perform session of action compulsory to manage prospective situations [9]. Adicondro & Purnamawati (in [10]) stated that students who had low self efficacy might not want to try to learn to face the exam because he considered that learning could not help him do the exam [10]. In addition, aspects of knowledge related to mathematical initial abilities of students in the high, medium and low categories are also a concern. This is because students' initial mathematical abilities can contribute to students' mathematical thinking skills [11]. According to [12] information about students' initial mathematical abilities can be used as consideration in developing the design and teaching materials that will be used during the learning process.

Based on the importance of the lecturer in knowing the geometry of students and gender in learning mathematics, this paper examines the geometry of students based on gender.

2. Methods
This research is an exploratory study by giving written tests to students. This research was conducted to explore a phenomenon that is relatively new with the aim of developing basic ideas on new topics, and providing a basis for further research [13].

The participants consisted of 90 people with 72 women and 18 men. Participants are students of the Department of Biology Education who are attending basic mathematics lectures in the first semester of the 2018/2019 academic year at one of the universities in Indonesia. In this lecture it is studied about coordinate systems, line equations (line equations and line gradients), and circle equations (definition of circles, equations of circles, tangents in circles), relations and functions, mathematical logic, and mathematical proof.

The research instrument was a test and non test. Non test instruments in the form of a Likert scale questionnaire compiled according to self efficacy indicators of 15 statements. In it there are answer choices from strongly disagree, disagree, agree and strongly agree. While the students' mathematical initial ability test instrument consisted of 20 multiple choice questions. Among the questions that have been translated into English are:

1. The following figure is a tangent circle with an equation $x^2+y^2 =100$ at the point that has abscissa 6.

   ![Tangent Circle](image)

   One of the equations of the tangent circle is ...
   a. $6x+8y=100$  b. $8x+6y=100$  c. $6x-8y=10$  d. $8x-6y=10$

2. Point A is located at the intersection of the two lines $y = x + 2$ and $y = 1 + 2x$. Here's the figure.

   ![Line Intersection](image)

   The line equation through point A and point O $(3,0)$ is ...
   a. $3x-2y=-3$  b. $3x+2y=9$  c. $3x-2y=9$  d. $-3x+y=-3$

3. The position of point C$(0,-4)$ to circle $x^2 + y^2 = 16$ is ...
   a. On the circle curve  b. inside the circle curve  c. Outside the circle curve  d. All wrong
4. The distance between the center of the circle $2x^2 + 2y^2 - 6x - 2y - 5 = 0$ from the y axis is ...
   a. 1.5  b. 2  c. 3  d. 6

Analysis of students' initial mathematical abilities is done by classifying them based on average and standard deviation [14], namely:

**Table 1. Criteria for grouping mathematical initial abilities (KAM)**

| Score interval                                    | Category        |
|--------------------------------------------------|-----------------|
| KAM ≥ average + standard deviation               | High            |
| Average - standard deviation ≤ KAM < average + standard deviation | Moderate       |
| KAM < average - standard deviation                | Low             |

The instrument of the geometry thinking level used test from CDASSG project from Usiskin [15] in the form of multiple-choice questions as many as 25 questions with the following details:

**Table 2. Questions distribution in the van Hiele levels**

| Question Number | 1-5 | 6-10 | 11-15 | 16-20 | 21-25 |
|-----------------|-----|------|-------|-------|-------|
| Level           | 0   | 1    | 2     | 3     | 4     |

As for the determination of the level of geometry thinking in Usiskin students, namely: will occupy level 4 if in each level can be answered correctly at least 3 items [15]. So, the placement of levels is the highest level which can be answered correctly at least 3 items in each level below. Naming the level of geometric thinking according to Dina van Hiele modified by Hoffer (Burger and Shaughnessy) [16]: level 0 or visualization, level 1 or analysis, level 2 or abstraction, level 3 or deduction, level 4 or rigor. Here is the description of the five levels of understanding in geometry according to van hiele theory [17] namely:

**Table 3. The van Hiele levels**

| Level | Explanation |
|-------|-------------|
| 0     | The learner names, recognizes, compares and performs on geometric figures by their mien. |
| 1     | The learner analyses figure in terms of their components and relationships among components and discovers rules/properties of a grade of shapes empirically. |
| 2     | The learner logically interrelates formerly discovered rules/properties by giving informal reasons. |
| 3     | The learner can prove theorems deductively and determine interrelationships in systems of theorems. |
| 4     | The learner can establish theorems in disparate postulational networks and appeals/analyses these systems. |

As for the properties in the level (van Hiele-Geldof) are as follows [15]:
- Properties 1: Students may not be at level n van Hiele without passing level n-1.
- Properties 2: At every level of the intrinsic idea at the previous level brings the extrinsic level now.
- Properties 3: Each level has its own symbol language and its own relation system that connects to the symbol.
- Properties 4: Two people who connect at disparate levels may not grasp each other.
3. Results and Discussion

The following is a data on the students' geometry ability in basic mathematics lectures.

| Table 4. The van Hiele levels for all students |
|-----------------------------------------------|
| The van Hiele levels | 0 | 1 | 2 | 3 | 4 |
| Number of students   | 23 | 46 | 4 | 0 | 0 |

Based on table 4 it can be seen that most students are at level 0 and level 1. And the results of the analysis of the results of student answers is known that as many as 17 students are only able to answer questions less than three in the number 1 - 5, meaning that students are at the level of pre-visualization. While the highest level that has just been achieved is level 2. This may be due to students of biology education programs and just following lectures and may be less fond of mathematics, especially geometry. These findings have similarities with [18], namely the highest level of thinking by van Hiele students at level 2 [19].

In contrast to the study of students in the 7th semester of the 2012/2013 Mathematics Education program who contracted geometry transformation courses, the number of students at level 0, level 1, level 2, level 3, and level 4 were respectively 7, 8, 11, 2, and 0 [15]. The findings are also different from Yudianto et al [3], that of 78 students who took analytical geometry courses as much as 11.54% were at level 0, 5.13% were at level 1, 1.28% were at level 2, 2.56% were at level 2, 2.56% were at level 3, 2.56% were at level 4, and 76.93% classified on the pre-visualization level. The following data on student geometry ability based on gender for male gender.

| Table 5. The van Hiele levels for male students |
|-----------------------------------------------|
| The van Hiele levels | 0 | 1 | 2 | 3 | 4 |
| Number of students   | 2 | 12 | 0 | 0 | 0 |

Based on table 5 it can be seen that 2 (11.11%) of the total male students are at level 0. As much (12) 66.67% of the male students are at level 1. While the remaining 4 (22.22%) are at the pre-visualization level. The following data on student geometry ability based on gender for female gender.

| Table 6. Geometry level data for female students |
|-----------------------------------------------|
| The van Hiele levels | 0 | 1 | 2 | 3 | 4 |
| Number of students   | 21 | 34 | 4 | 0 | 0 |

From table 6 it can be seen that the number of female students is 29.17% at level 0, 47.22% at level 1, and 5.55% at level 2. While the remaining 13 people (18.05%) are at the pre-visualization level. Based on these results there is a difference between male and female students. There are no male students reaching level 2. This is consistent with Ismail's statement that "More female students have always performed male students in their educational attainment" [7]. Zubaidah also reported that the reality in the field did not show that female students also excelled in mathematics [6]. Unlike the findings of Alifah which shows that the level of thinking of male students is at level 1, the level of thinking of female students is at level 1, and in general there is no difference between the level of thinking of male and female students [20].

Based on these results, there were no students who reached level 3 and level 4. This was possible because participants were first semester students in the biology department who tended to have low self-efficacy towards mathematics. The following are self-efficacy data and students' initial mathematical abilities.
Based on Figure 1, 43 (47.8%) students had self-efficacy of less than 3 (below the neutral score) which was negative. Nearly half of the students have negative self-efficacy, and are spread in groups of students with low, moderate, and even high initial mathematical abilities. So that this self-efficacy affects the level of student geometry thinking. Because students whose self-efficacy is low may not want to try to learn and assume that learning cannot help them do the exam [10].

Teaching materials and models/methods/strategies/approaches/learning media are needed which can facilitate gender differences, self-efficacy, and mathematical initial abilities so that the level of students' geometric thinking abilities increases.

4. Conclusion
The results showed that from 18 male students as many as 4 people were at the level of pre-visualization, 2 were at level 0, and 12 were at level 1. Whereas of 72 female students, 13 were at pre-visualization level, 21 were at level 0, 34 people are at level 1, and 4 people at level 2. Based on these results there is a difference between male and female students, namely some female students reach level 2, but not male students. So that overall the highest level achieved by students is only level 2. This might be because students are biology teacher candidates who have low self-efficacy towards mathematics. To improve students' geometry abilities teaching materials and models/methods/approaches/media of learning are needed. So that further research is needed.

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