Geometry verbal skill of field dependent-independent students in junior high school according to van hiele thinking level

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Abstract. This research aimed to describe the geometry verbal skill of FD-FI students in Junior High School at level 1, level 2 and level 3 according to Van Hiele Theory. This research was a survey. This research was conducted for grade 8 students of junior high schools. The samples were selected using proportionate stratified random sampling technique which was a combination of stratified sampling technique and proportional sampling technique followed by random sampling technique. This technique was used to determine the sample proportionately for each strata. The samples consisted of 4 representative high strata schools. The data were collected using tests and interview. Data analysis technique consists of data reduction, data display, and data conclusion. The result showed that: (1) FI students level 1, 2 and 3 get a better result than FD students to associate the correct name with a given properties and to define a figure accurately and concisely by showing interrelations between figures, (2) FD students is better than FI students to define a figure accurately with various properties, (3) From 103 students, there is only one FI student at level 3 can answer definition of figure perfectly.

1. Introduction

In education, it is important to students to master the subjects they have learned for their great future. One of the subject is mathematics. Mathematics becomes the basic of science to develop others science [1]. Because of that, one of the goal learning mathematics is to prepare the students to face life challenge in this growth century [2]. Geometry is one of important branch in mathematics because it is applied in so many aspects of life [3]. Nevertheless, it often becomes a neglected topic in the curriculum [4]. In fact, there are many problems in learning geometry. This is indicated with research by Bjuland about geometry reasoning, it showed that many students have difficulties to solve problem which related to geometry concept [5]. Gunhan in his study also found that students still can’t use geometry concept well to solve problems [6]. Furthermore, research by Hartono showed that students still have difficulties to identified unusual geometry shape and don’t understand the properties of geometry shapes well [7]. Students also often make misconception when learning geometry at class [8]. Observation result in this research also showed that some students still can’t identify a figure from its properties correctly and still can’t make a definition of a figure perfectly.

Related to those geometry problems above, Van Hiele proposed his theory to measure students geometry capability which based on student’s thinking so that this theory is assertive [9]. Van Hiele theory consists of five level, level 1 (visualization), level 2 (analysis), level 3 (abstraction), level 4 (deduction), and level 5 (rigor) [9]. At level 1, students just recognize figures by appearance and they don’t use reasoning to make decisions, but it’s just based on their perception. At level 2, students just recognize and name properties of geometric figures but they don’t see relationships between these properties. They just describe an object by making list all the properties without seeing which properties
are necessary and sufficient to describe the object. At level 3, students can make definition of an object by perceiving relationships between properties and figures, such as squares being a type of rectangle. At level 4, students should be able to construct proof, understand the role of axioms and definitions and know the meaning of necessary and sufficient conditions. At level 5, students understand the use of indirect proof and proof by contrapositive, and can understand non-Euclidean systems [10].

Hoffer made Van Hiele theory largely to bring it in description of skills for each level area. There are five skills in each level of Van Hiele, visual, verbal, drawing, logical and applied [11]. He integrated these skills as the second dimension to the Van Hiele level. Visual skill is related to spatial skills and visual perception [12]. Spatial orientation include organizing, recognizing, understanding visual representation, reseeing it or seeing it from a different angle, but not mentally moving the object [13]. In verbal skill, a good definition has to consist of classified term and different from other similar term. Students have to have good writing ability to create a good explanation. Drawing skill is an ability to apprehend the main part of problem which is represented in physical word or through a verbal description. At logical skill, it is actually related to verbal skill and visual skill. Students involve using definition and theorems to justify conclusions. To develop a logical argument requires the right of using vocabulary and language. Students also use their visual skill to focus on certain details in an image, which is most directly related to logical skill. Applied skill is the relation between mathematical modes and physical phenomena. Students can represent physical phenomena in a mathematics model [14].

In learning geometry, students also have different ways to express their thinking. Those differences are called cognitive styles [15]. Cognitive style affects student's thinking, learning and academic development. Because of that, it must be interesting and useful to link up the cognitive styles with the van Hiele levels of geometric thinking [16]. One of cognitive style that has been widely researched is field dependent-independent [17]. Field dependent (FD) students think globally and they need guidance in learning, while field independent (FI) students think analytically and they can learn something by themselves without any guidance from teacher [18].

Based on the explanation above, teachers need to know students’ geometry skill based on Van Hiele thinking level and their cognitive styles. It makes teachers easy to give compatible treatment to each students. So it is necessary to know geometry skill of field dependent-independent students according to van hiele thinking level. In this research, we will discuss only about geometry verbal skill in high-stratified schools.

2. Method

This study was a survey. The population in this study was 8th graders with age range 14-15 at 36 schools. The size of the population is so large, because of that, the sample selection actually represents the population which notices the strata in the population. Sampling technique uses stratified proportional random sampling. The grouping of the school strata is based on the level of the mathematics score group of the National Examination in 2016/2017. There were four high-stratified schools and it took a class in every school for sample.

The data in this study were collected by using tests and interview. The test instruments in this study were Group Embedded Figures Test (GEFT), Van Hiele Geometry Test (VGHT), and geometry visual skill test. GEFT has been developed by Oltman, Raskin, and Witkin (1971) to assess field dependent-independent student [19]. There were 3 sections with 25 complex figures in this test, and it took 15 minutes to finish the test. Students will be in FD group if GEFT scores is in range 0-11, and if GEFT scores above 11, students will be in FI group [20, 21].

VGHT was developed by The Cognitive Development and Achievement in Secondary Geometry Projects (CDASSG). VGHT is designed to measure students' thinking level in geometry. The test consists 15 multiple choice questions that are arranged in sequence. Each level is represented by five questions and it took 20 minutes to do the test. Students can be at a certain level if they can answer 3 questions correctly.

Furthermore, students were given a matter of geometry skills test according to Hoffer. The test consists 1 essay verbal skill question. It consists of 2 questions to measure 3 indicators in verbal skill: (1) to associate the correct name with given properties, (2) to define a figure accurately with various properties, and (3) to define a figure accurately and concisely by showing interrelationships between figures. Question number one is to measure first indicator and question number two is to measure second and third indicator. It took 25 minutes to do the test. In this study, interview was used unstructured interview according to developed interview guidelines. The validity of instrument in this study is content
validity obtained from expert judgement. The validity of this study was viewed by language, content, and construct.

Procedure in this study started from giving GEFT to four classes to know cognitive style of students to become field dependent-independent students group. Furthermore, students answered VGHT to measure students' thinking level in geometry, and the last test was to answer geometry verbal skill to know students' verbal geometry. Collected data was analyzed by using steps consists of reduction data, display data, and conclusion data [22].

3. Result and Discussion

The first test was to answer GEFT, then students did VGHT. The result can be seen at Table 1.

Table 1. Result of GEFT and VGHT in four schools.

<table>
<thead>
<tr>
<th>School</th>
<th>Cognitive Style</th>
<th>Van Hiele Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FD</td>
<td>FI</td>
</tr>
<tr>
<td>A</td>
<td>13</td>
<td>15</td>
</tr>
<tr>
<td>B</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>C</td>
<td>18</td>
<td>3</td>
</tr>
<tr>
<td>D</td>
<td>15</td>
<td>9</td>
</tr>
<tr>
<td>Total</td>
<td>60</td>
<td>43</td>
</tr>
<tr>
<td>Percentage</td>
<td>58.25</td>
<td>41.75</td>
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</tbody>
</table>

There are two schools which have higher percentage of FI students. But overall, the percentage comparison between FD and FI students is not too much different. The difference is 16.5%. Generally, most of students are in level 1. There are 80 students from 103 students in this level. This is appropriate with Walle, he stated that high school students could be at level 1 [23]. There are three students in level 3 from three schools. Only one school which can not achieve to level 3. This is similar with a research conducted by Mayberry who found that 70% of students were under level 4 [24].

After students finished GEFT and VGHT, they did geometry verbal skill test in essay form. The test result is grouped by cognitive style and van hiele level (VHL). To look the comparison between FD and FI students from each van Hiele level, it uses the average of each question number. The question consists of two questions, a and b. At question a, students were asked to associate the correct name with given properties. This kind of the question is verbal skill at level 1 dimension of van hiele. Question b was asked about definition of figures, rectangle and square. This question is looked by two levels of Van Hiele. For students who can answer by showing interrelationships between figures, their verbal skill is at level 3 of van hiele, but if they just mention various properties to define figure, their verbal skill are just at level 2 of van hiele. The result can be seen at Table 2.

Table 2. Geometry verbal skill test result grouped by cognitive style and van hiele level

<table>
<thead>
<tr>
<th>Cog style</th>
<th>VHL</th>
<th>Σ students</th>
<th>Qst a</th>
<th>X max</th>
<th>Σ students</th>
<th>Qst b</th>
<th>X max</th>
<th>Σ students</th>
<th>Qst b</th>
<th>Xmax</th>
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<td></td>
</tr>
<tr>
<td>FI</td>
<td>1</td>
<td>30</td>
<td>1.95</td>
<td>2</td>
<td>24</td>
<td>1.18</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>1.37</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>11</td>
<td>1.90</td>
<td>2</td>
<td>9</td>
<td>1.67</td>
<td>4</td>
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<td>1.5</td>
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<td></td>
<td>3</td>
<td>2</td>
<td>2.00</td>
<td>2</td>
<td>1</td>
<td>2.00</td>
<td>4</td>
<td>1</td>
<td>2.00</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 2 shows that FI students at level 1, level 2, and level 3 of Van Hiele have better result than FD students to associate the correct name with a given properties and to define a figure accurately and concisely by showing interrelationships between figures according to level 1 and level 3 dimension of Van Hiele. Almost all FI students test result is better than FD students test result. This is line with research conducted by Tinajero that field independent students have been shown consistently to obtain better academic result than field dependent students [25]. Only in question b at level 2 dimension of Van Hiele, field dependent students result are better than field independent students to. It is because many FI students did not write the complete information about requested question of figure definition, but in fact they know the complete answer. So it makes their score result is below FD students.
All FD students at level 1 could answer question a. But at question b, 46 of them are at level 2 category and two are at level 3 category. It means there are two unidentified students at table. These two students are between level 2 and level 3. They can define one figure by showing interrelationships between figures, but they just define another figure by mentioning its various properties. The similar problem also happens to FD students at level 3, FI students at level 1 and level 2. For all FD and FI students, most of them did not answer question b completely, we can see the maximum average score for question b is 4, and the highest score which almost attained is only 2. From 103 students, there is only one FI student at level 3 can answer definition of figure perfectly.

The following figures describe some students’ answer of FD and FI.

### 1. FD Student

![Figure 1](example.png)

**Figure 1.** example of FD student’s answer

Figure 1 shows example of student’s answer to associate the correct name with given properties. We can see that student answers square, rectangle, rhombus, and equilateral triangle. Student answers two correct answers, and the others are incorrect. Student has difficulties to associate the correct figure name with given properties. From interview result, they also have doubt about their answer, they could not maintain their answer and they could not explain well about their answer, because they don’t understand the properties of geometry shapes well. This is the same problem with Hartono research result [7]. A bit different to question b in figure 2, student defines good enough figures by mentioning some its properties, although there is the properties of the rectangle and square are not yet appropriate. This result is supported with Rayner and Riding who state that FI students are better than FD students in analysis [26]. Many FD students could not finish this question perfectly. They need more guidance to complete the question correctly [18].

### 2. FI Student

![Figure 2](example.png)

**Figure 2.** example of FD student’s answer

Figure 2 shows a little difference to figure 1. Student defines good enough figures by mentioning some its properties, although there is the properties of the rectangle and square are not yet appropriate. This result is supported with Rayner and Riding who state that FI students are better than FD students in analysis [26]. Many FD students could not finish this question perfectly. They need more guidance to complete the question correctly [18].

### 3. FI student

![Figure 3](example.png)

**Figure 3.** example of FI student answer

Figure 3 shows that students could answer question a perfectly. They analyze very well to associate the correct figure name with given properties as Rayner and Riding said [26]. Although there are some FI students could not do correctly, but it is just a small number of them. Most of them could finish this question correctly without any guidance from teacher [18]. It looks contrast to question b, student could answer this question but they just mentioned one property of a figure. This happened to many FI students. From interview result, actually they know well about figure properties, but they just did not write those all to answer the question. Because of that, FD result is better that FI result in this question. It causes the opposite result with Tinajero research [25].

3. FI student
Figure 4 above also shows FI student answer. But we need to explore more to this answer. In question a, student could analyze to associate the correct figure name with given properties very well. It is just the same with others FI students. In question b according to level 2 of Van Hiele, student could define rectangle by showing interrelationships between rectangle and parallelogram, but still not correct. The student have ability to find interrelationships between rectangle and parallelogram. But student could not define square by showing interrelationships between figures. Student only defines square by mentioning its property. The similar problem also happened to some students in this research. This indicates that student is neither in level 2 nor level 3.

4. Conclusion

Based on the results of research and data analysis, it can be concluded that FI students from high strata schools at level 1, 2 and 3 according to Van Hiele theory get a better result than field dependent students to associate the correct name with a given properties and to define a figure accurately and concisely by showing interrelationships between figures. But FD students is better than FI students to define a figure accurately with various properties, it is because many FI students did not write the complete information about requested question of figure definition, but in fact they know the complete answer. So it makes their score result is lower than FD students. But generally, most of FI students get a better result than FD students at each level of van hiele. From 103 students, there is only one FI student at level 3 can answer definition of figure perfectly. Because of time and participant number limitation, this study needs suggestion and improvement in the next study.

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