The Effort to Teach PGSD Students in Developing Geometry Learning Method Based on Van Hiele's Theory

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Abstract

The purposes of this study are 1). To describe the activities of lecturers in improving the PGSD Unnes students' ability to design the learning of geometry based on Van Hiele's theory. 2). To describe the activities of students in improving the ability to design the learning of geometry based on Van Hiele's theory 3). To know the students' learning outcomes in developing learning activity of elementary geometry by implementing Van Hiele's theory on PGSD students UNNES. This research is a classroom action research conducted in two cycles and each cycle consists of two meetings. Each cycle consists of planning, execution, observation, and evaluation. The subjects of this study are lecturers of geometry and students who take geometry course. The technique in collecting data is using test and non-test techniques. The data analysis is done in quantitative and qualitative descriptive analysis. The result shows that all students can achieve mastery learning. It is suggested that a set of task bills so that prerequisites have been owned by the students. Structured tasks should be given to see the students' ability.

Keywords: geometry, van hiele's theory, elementary school, Unnes

1. INTRODUCTION

In accordance with three obligations of higher education (tridharma), lecturers have three main obligations which are related to each other. The first obligation is related to education and teaching. The second obligation is doing research. The third obligation is doing community service. Education and teaching is the main obligation of lecturers although other two obligations cannot be left.

In the law of Republic of Indonesia number 20 of 2003 about the national education system, in article 1 it is mentioned that education basically is a conscious effort to improve the competence of students by encouraging and facilitating the learning process. The effort to improve the university students includes some factors such as curriculum and learning method which are the vital components that can lead the learning process to be effective and in accordance to the objectives of the study made. One of the characteristics of mathematics learning nowadays is the presentation which is based on the learning psychology. Understanding the learning theory from the psychologists is very important to the success of mathematics learning process in the class. By understanding the available learning theory, lecturers are expected to be able to design and execute the learning process in their class well by referring to the learning theories (Shadiq, 2011). In accordance with the importance of mathematics learning theory in the learning process in the class, it is a must to adjust the learning theory asserted by educational experts to every learning method. It is important not only to make sure the level of concept substance given to the students but also to adjust to their competences, so is its teaching method. The lecturers should understand the students' level of improvement and how the teaching should be done according to the right steps. The students of PGDS are prospective teachers, so that it is important for them to design the mathematics learning including geometry by implementing the theory by Van Hiele, the figure of geometrical learning theory.

Geometry is a branch of mathematics which is taught in every level of education, from elementary level to higher education level. Geometry is a branch of mathematics which is very near to students' daily life since almost every single visual object around them is geometrical object. Freudenthal (Afgani, 2011) asserted that geometry is room of kids. In that room, kids should learn to know, explore, conquer, plan and manage in order to live, breathe, and do something better. Usiskin (1982) gave some reasons why geometry is important to be taught. The first reason is geometry is the only branch of mathematics which relates mathematics to physical form in the real world. The second, geometry is the only branch of mathematics which is possible to visualize the mathematical ideas. The third, geometry can provide a non-singular example of a mathematical system. In the process of learning geometry, the students will have some sequenced stages of thinking.

In 1959 in Netherland, Piere van Hiele and his wife Dieke van Hiele Geldof asserted a theory about the process of growth experienced by students in learning geometry. Sequenced stages of thinking experienced by the students in learning geometry according to Van Hiele are as follows:

Stage 0 (visualization): this stage is also called cognitive stage. In this stage, the students see a geometrical figure as a whole. In this stage, they have not focused on the components of every geometrical figure.

Stage 1 (analysis): this stage is known as descriptive stage. In this stage, the students have known geometrical figures based on their characteristics. In other words, in this stage the students have accustomed to analyze parts of a figure and observe characteristics of those elements.

Stage 2 (informal deduction): this stage is also called sorting stage or relational stage. In this stage, the students have been able to understand the relation between one characteristic to other characteristics of a figure.

Stage 3 (deduction): In this stage, the students have understood the role of basic notions, definitions, axioms, and theorems in geometry. In this stage, they have been able to arrange the proofs formally.

Stage 4 (raigor): this stage is also called metamatic stage. In this stage, the students are able to reason formally about mathematical systems (including geometrical systems) without concrete models as references (Crowley, Mary L., 1987).

In improving a stage of thinking to another higher stage, Van Hiele asserted a learning process including 5 phases (steps). They are information, directed orientation, explication, free orientation, and integration.

1.1 Information Phase

This phase is the first phase to know the basic understanding of students about the topic to study with questions and answers between teacher and students about objects to study in analysis stage.

1.2 Directed Orientation Phase

This phase is the second phase done in the learning method based on the theory by Van Hiele. In this phase, the teacher directs the students in observing the special characteristics of the studied objects through tasks given by the teacher.

1.3 Explication Phase

In this phase, the students are directed to express their opinions about relation of geometrical concepts with their own ideas (for example about the characteristics of observed geometrical figures).

1.4 Free Orientation Phase

In this phase, the students face more complex tasks which can be done or solved by many ways and steps.

1.5 Integration Phase

In this phase, the students summarize and conclude the materials they have learned by making a relation among observed geometrical objects (Crowley, Mary L., 1987).

The fact in the field shows that the effort of PGSD students to have the precondition knowledge autonomously before the class is still low which also affects the learning outcomes. It can be seen that the PGSD students' ability in implementing the theory of Van Hiele on geometry is 70% less proficient, 30% proficient enough, and no one has reached proficient category. It can be seen that the students' lesson plan that should be made in every phase is less precise. It may be cause by the academic atmosphere they have not felt. It can be seen from 18 groups of students (91 students) in developing learning indicators and objectives that only 2 groups are correct. By doing observation and interview it is found that they have not read the needed literatures even they did the tasks based on their own opinion which is not referred to the materials in curriculum and learning theories. It can be seen that the students have less effort, less responsibility, and less hard work. According to this finding, it is important to build the character of academic culture to improve their ability in developing geometrical learning based on the theory of Van Hiele.

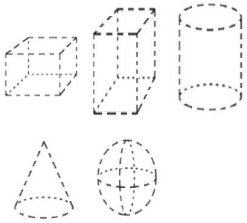
There are some conducted researches which support this research. The first research was conducted by Safrina, Ikhsan, and Ahmad (2014). They asserted that the ability to solve the geometrical problems based on the theory of Van Hiele shows that the experimental group is better than the control group. The second is a research conducted by Muhassanah, Suryadi, and Riyadi (2014) that found every student in a class has different levels of thinking and needs geometrical ability to solve geometrical problems.

This research aims to observe how to teach PGSD Unnes students in developing geometrical learning method based on the theory by Van Hiele.

2. RESEARCH METHODOLOGY

The subjects of this research were the lecturers of mathematics and the students take geometrical learning course and measurement which consist of

27 students. This research was conducted in PGSD Unnes. The procedures done in the research is

PHASES	INDICATORS	ACTIVITIES
Phase 1 (Information)	3.6.1 Mentioning the names of solids appropriate to the objects in the classroom and around the school.	The teacher provides some concrete media. For example:  The teacher asks the students to mention names of the solids from these things.
Phase 2 (Orientation)	3.6.2 Mentioning the names of things around them appropriate to solids.	The teacher asks the students to choose a solid, then the students write the names of objects around the classroom and the school according to the solids as much as possible. 
Phase 3 (Explication)	4.6.1 Presenting their findings about names of things around them that match to solids.	The students present their findings in previous activities. For example: beam-shaped object are books, erasers, cardboard shoes, cupboards, etc. The teacher provides various images of objects. Then, the students are required to group the objects in accordance with the specified plane. 
Phase 4 (Free Orientation)	4.6.2 Grouping some things that match to the names of predetermined solids 4.6.3 Thickening the dotted lines which form a certain solid.	The stud contains a picture of dotted lines, then they are asked to thicken the dotted line. 
Phase 5 (Integration)	4.6.4. Making a conclusion of grouping things activity.	The students present their result of the activity they have done. For example: - The things number (5), (7), (11), and (16) are spheres. - The things number (2), (3), (6), and (12) are tubes. - Etc.

classroom action research. In accord with Arikunto (2010), classroom action research is a scrutiny of learning activities in a form of a conscious effort and happens in class altogether. The recycle in this classroom action research is initiated with planning, action, observation and evaluation, and reflection, and so on until the expected improvement or increase is reached (successful criteria).

3. FINDINGS AND DISCUSSION

This classroom action research was done in 2 cycles of research which consists of 2 meetings. The followings are the research results including lecturers' activities, students' activities, and the geometrical learning outcomes of PGSD Unnes students.

In each cycle, before the class, the students are asked to review the elementary schools' curriculum about geometry. The students are divided into 6 groups. Group 1 reviews the geometrical curriculum for class 1, group 2 reviews class 2, group 3 reviews class 3, group 4 reviews class 4, group 5 reviews class 5, and group 6 reviews class 6. In cycle 1 meeting 1, group 1, 2, and 3 report their results of discussion on reviewing the elementary schools' curriculum. At the meeting 2, group 4, 5, and 6 report their results of discussion on reviewing the elementary schools' curriculum about geometry of class 1 to 6 of elementary school.

Based on the observation on the students' activities, it can be seen that from 6 observers, the average of students' learning motivation aspect and courage aspect is still in medium category with score 2. While their participation, interaction during the learning process, and mathematical communication are in good category. Based on the results of lecturers' activities observation, it can be seen that there is only one aspect in medium category for presented media in learning aspect with score 2 and assessment is in good category with score 3, and for creating supportive class atmosphere and in materials quality 9 of them are in very good category with score 4. Based on the last evaluation cycle 1, the students' learning outcome can be seen that 5 students can reach the learning completeness (75), and 22 students have not completed (<75).

The researchers team conduct an evaluation in finding the students' activities aspect which still needs to be improved. It is the learning motivation and courage of the students. The aspect which needs to be improved is students' participation, interaction, and mathematical communication.

While the result of lecturers' activities observation aspect that need to be improved is media quality. An aspect that need to be improved is students' learning readiness preparation and student learning motivation improvement, learning process, and assessment. Aspects that need to be maintained is creating an atmosphere of learning and the quality of the material presented. From the assessment results, it can be seen that 22 students have not

completed learning. Since all aspects are not in good category (does not meet the success indicators), an action needs to be continued in the next cycle.

In cycle 2, the materials assigned to be studied before the class is Van Hiele's theory and its implementation. The first cycle 2 group meeting of groups 1,2, and 3 is implementing the results of the discussion. Meeting 2, groups 4, 5, and 6 present the results of the discussion. Geometry learning process is done by implementing Van Hiele's theory by analyzing the basic competencies for geometry at which level according to Van Hiele's theory. From the result of basic competence analysis for the geometry in elementary school is at level 1 (introduction), 2 (analysis), and 3 (sorting) of Van Hiele's theory. Furthermore, the learning process was developed based on the phases of Van Hiele's theory. The following presents consecutively geometry learning level 1 (introduction), 2 (analysis), and 3 (sorting).

Geometry learning class 1 for the following basic competences (KD):

3.6 Recognizing solids and plane by using various concrete objects.

4.6 Grouping solids and plane based on certain characteristic using various concrete objects.

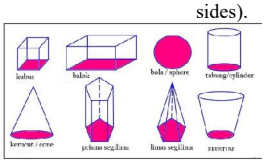
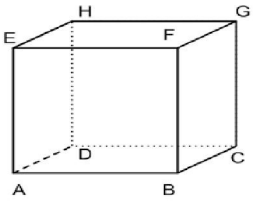
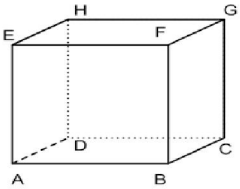
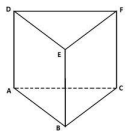
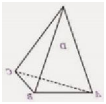
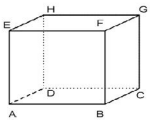
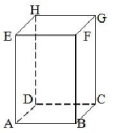
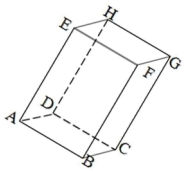
Those basic competences (KD) at the stage 1 is the level of introduction: at this stage, new students recognize solids They can choose and show the shape of cubes, beams, etc. They classify solids based on their form. The learning steps are based on the following phases of Van Hiele as follows:

Here are the learning steps for basic competences at level 2 of Van Hiele's theory.

Basic competences

3.8 Explaining the line segment using the concrete models of plane and solids.

4.8 Identifying the line segment using the concrete model of plane and solids.

PHASES	INDICATORS	ACTIVITIES
Phase 1 (Information)	3.8.1 Mentioning line segment that limits solids.	The teacher provides various shapes. Then, the students are guided by the teacher to know the line segment that limits the solids (by showing the sides). 
Phase 2 (Orientation)	3.8.2 Identifying the characteristics of line segments through the observation of concrete objects.	The students choose a form of geometrical frame, then observe the solids. Then they observe the solids and determine the characteristics of the line segment of the geometrical framework they choose.
		 Through the framework of solids, students can mention many line segments that limit the solids.
Phase 3 (Explication)	3.8.3 Mentioning the number of segments in the triangle solids and rectangular through the concrete object.	  The students look for similar forms with many segments. So, they are able to show line segments including side and not side.
Phase 4 (Free Orientation)	4.8.1 Grouping up solids based on the number of segments.	   
Phase 5 (Integration)	4.8.2 Shaping a solid image from many restrictive line segments.	The students with teacher guidance, draw the solids by connecting the available dots. 

Class 3 geometry learning for the basic competences which includes level 3 (sorting) van Hiele are:

Basic Competences

3.12 Analyzing the various planes based on the characteristics they have.

4.12 Grouping various planes based on the characteristics.

The learning steps are based on the following phases of Van Hiele's theory.

<table>
<tr><th>PHASES</th><th>INDICATORS</th><th>ACTIVITIES</th></tr>
<tr><td>Phase 1 (Information)</td><td>Mentioning the characteristics of planes.</td><td>The class is begun by questions and answers about the characteristics of planes (parallelogram, rectangle, split, square, trapezoid, and kite).
a. The students mention the characteristics of planes using the following table format. The students write down the characteristics of planes in the table below:<table><tr><td>Plane's Name</td><td>Characteristics</td></tr><tr><td>Square</td><td></td></tr><tr><td>Rectangle</td><td></td></tr></table>b. The students find the planes' names which their characteristics are determined using the following table format:<table><tr><td>Plane's Characteristic</td><td>Plane's Name</td></tr><tr><td>1. The opposite sides are the same and parallel.
2. The facing corners have the same size.</td><td></td></tr><tr><td>1. The opposite sides are equal and parallel.
2. The facing corners have the same size.
3. The four sides have the same length.</td><td></td></tr></table></td></tr>
<tr><td>Phase 2. (Orientation)</td><td>Finding the plane which its characteristic is determined.</td><td></td></tr>
<tr><td>Phase 3. (Explication)</td><td>Communicating the plane which its characteristic is determined.</td><td>The students display their findings about the planes' names which their characteristics are determined.
The students do the tasks to find:
a. The relation between the rhomb and parallelogram using the following table format:<table><tr><td>Plane's Name</td><td>Characteristic</td></tr><tr><td>Rhomb</td><td></td></tr><tr><td>Parallelogram</td><td></td></tr></table></td></tr>
<tr><td>Phase 4. (Free Orientation)</td><td>Finding the relation among planes.</td><td>The students write down the same characteristics between rhomb and parallelogram in the following table.<table><tr><td>Plane's Name</td><td>Rhombs</td><td>Parallelogram</td></tr><tr><td>Characteristic Sameness</td><td></td><td></td></tr></table>By observing the characteristic sameness between rhomb and parallelogram, the students are guided to find the relation between them.</td></tr>
<tr><td>Phase 5. (Integration)</td><td>Summarizing the names of planes that their characteristics are determined and making a chart related to the relation among planes.</td><td>The students with teacher's guidance make a summary about the planes' names which their determined characteristics and make a chart of relation among planes.</td></tr>
</table>

From the observation result, it can be seen that from six observers after the score's average is made, the students' participation aspect is in excellent category (scale 4), the students' interaction during learning, mathematics communication, motivation, and courage are in good category. The observation of lecturers' activity shows that there is one aspect in medium category (2) that is related to the presented media. The final evaluation result of cycle 2 shows that all students can achieve learning completeness and mastery.

4. CONCLUSION AND SUGGESTION

The conclusions of this research are presented as follows. The students' ability in designing geometry learning based on the theory of Van Hiele can be improved by increasing and adding students' activity, lecturers' activity, and students' learning outcomes.

The proposed suggestion is that in learning geometry, paying attention to the basic competencies to be taught at certain level in accordance with Van Hiele's theory is a very important thing. It is also

essential to design the learning plan through the phases of Van Hiele's theory.

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