Van Hiele Theory to Improve Higher Order Thinking Skills in Geometry

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Abstract—Nowadays, education requires students to have conceptual knowledge and skills in thinking and understanding. Higher order thinking skills (HOTS) is one of skills that required in improving skills of thinking process. HOTS are one of skills that students required to face competition globally. Students’ understanding in geometry subjects also should be improved. One theory of learning in geometry which fit to improve conceptual knowledge and higher order thinking skills is a learning theory Van Hiele. Learning theory Van Hiele can build understanding of the concept of geometry includes four levels, namely level 0 (visualization), level 1 (analyze), level 2 (abstraction), level 3 (deductive) through five stages: stage 1 (Information), stage 2 (guided orientation), stages 3 (explicitation), stage 4 (free orientation), and stage 5 (integration). Learning theory Van Hiele can improve student’s HOTS because: (a) the learning process by using learning theory van hiele can empower students to construct knowledge; (b) effectively used in learning individually or in groups; (c) as a variation in learning activities to improve student’s skills; (d) as a learning process to manage student’s conceptual of geometry.

Keywords: Van Hiele Theory, higher order thinking skills, geometry

I. INTRODUCTION

Education is basically prepared to equip students to be able to think in a rational, critical, creative, logical, and higher level thinking and systematic thinking is correct in dealing with the problems of life. One of the goals of education is to help someone in studying various things not knowing that they were able to cultivate the talent and potential that they have. With the education of students expected to meet the needs for today and the needs of students to come. The needs of students who will come is that students have the skills to think critically and creatively in society that will be able to compete with other nations and excel in the field of Science and Technology (Science and Technology).

Mathematics is one of the basic science that is taught in every level of education, from primary education up to college. Mathematics plays an important role in educating learners because it can develop logical thinking skills, analytical, systematic, critical, creative and ability to cooperate. This is consistent with the Content Standards in Government Regulation No. 22 of 2006 which states that "mathematics is a need for learners to equip learners with the ability of logical, analytical, systematic, critical, creative, and ability to cooperate.

In the 2013 curriculum development, learning mathematics includes critical thinking skills and creative thinking that is the purpose of learning. Critical thinking is one of the educational goals that require exercises to improve the ability to think critically and make decisions about what to do and believed. According to Dewey (Fisher, 2008: 2) states that critical thinking is to consider actively, constantly, and meticulous about a belief or form of knowledge in light of the reasons which support it and the conclusions that become trends. Nurhadi and Senduk (2009: 86) states that the purpose of critical thinking is to create a spirit of critical thinking that encourages students to question what they hear and examine their own mind to ensure there is no logic to inconsistent or erroneous.

Creative thinking is defined by Isaksen et al (Grieshober, 2004) as the construction process ideas that emphasizes the aspects of fluency, flexibility, novelty, and of detail. According to McGregor (Ali Mahmudi, 2010: 2) creative thinking is the thinking that led to the acquisition of new insights, new approaches, new perspective, or a new way of understanding things. Critical thinking is supported by the problems that challenge. According to Martin (Ali Mahmudi, 2010: 2) three aspects of creative thinking ability is productivity, originality, and flexibility.
Both of these skills, namely critical thinking and creative thinking, including in high-level thinking skills criteria (higher order thinking skills). Higher order thinking skills (HOTS) is a thought process that consists of components of critical thinking and creative thinking (Conklin, 2012: 4). Higher order thinking skills are very important in the learning developed especially for the learning of mathematics in solving unusual problems require both these capabilities, the ability to think critically and creatively. In helping students create their own knowledge, the main task of the teacher is to create activities or environments that allow students to engage in higher-level thinking activities. Brookhart (2010: 6) mentions the learning objectives to develop HOTS is to equip students skilled in giving reasons, describe and make a decision. A crucial aspect of higher order thinking skills to support students to think logically, creative, critical, and metacognitive, but it also trains students to solve problems that have not been met.

Low ability students' higher order thinking in mathematics in Indonesia indicated from the data survey conducted by TIMSS in 2011 are reviewed in three aspects, namely: knowledge, application and reasoning as in Table 1 below (Mullis, Martin, Foy, & Arora, 2011: 150).

<table>
<thead>
<tr>
<th>No</th>
<th>Capability category</th>
<th>Average</th>
<th>Maximum Score</th>
<th>Minimum score</th>
</tr>
</thead>
<tbody>
<tr>
<td>38</td>
<td>Knowing</td>
<td>378</td>
<td>616</td>
<td>331</td>
</tr>
<tr>
<td></td>
<td>Applying</td>
<td>384</td>
<td>617</td>
<td>316</td>
</tr>
<tr>
<td></td>
<td>Reasoning</td>
<td>388</td>
<td>612</td>
<td>322</td>
</tr>
</tbody>
</table>

The data above show that cognitive achievement in mathematics which measures three aspects of the ability is still in the low category. This is because the category of questions that tested a new thing for the students and not because of the inability of students to solve problems given.

Fauzan research results (2002: 30) shows that the understanding of most students at the junior level of the concepts of geometry (e.g., a square, a parallelogram, and triangles) is still low. They can not recognize these objects even though they have studied since the base rate. Not much different from the results of the TIMSS 2011 on domain knowledge, the analysis of the absorption of students based on the results of the National Examination (UN) on the geometry also show that such knowledge need attention.

Based on these facts, we conclude that there is still a capability that needs to be improved. One of them is the high level of students' thinking skills that include critical thinking skills and creative thinking ability. Teachers doing activities during the learning process too monotonous and still traditional, which is centered on the teacher. This makes the interest of students to the learning process tends to be boring. In addition, the difficulty of learning the math does not fit the model applied learning in the classroom so that students do not manage to understand the material when studying mathematics.

Van Hiele learning theory is a theory in the teaching of geometry, which outlines the stages of mental development of children in geometry. According to this theory, there are three main elements in the teaching of geometry that time, teaching materials and teaching methods are applied. If all of them arranged in an integrated manner it will be able to enhance the thinking ability of children to a higher level.

Van Hiele theory states that there are five stages of a child's learning in learning geometry, namely the introduction stage, the stage of the analysis, the sorting stage, the stage of deduction, and phase accuracy. Based on the understanding of the geometry stage explained that students can not reach a stage of thinking without going through the previous stage. Not forgetting inherent in Van Hiele theory that, in understanding the geometry, one must go through the level sequentially. This is referred to as the ordered nature of these levels. Van Hiele theory also has three unique characteristics: elegance, comprehensiveness, and wide applicability. Elegance means that the theory using a simple structure that is illustrated with concise statements with great effect. For example, the same principles are used to move from level 1 to level 2 from level 2 to level 3 and so shows a graceful shape. Then the simplicity of its structure, becomes evident when one knows that the knowledge-knowledge at level 1 is the foundation for the properties at level 2, which is then sequenced at Level 3, the order of the main prerequisite for understanding the system of mathematics at level 4, one of the objects the compared at level 5.

Based on the above description shows the importance of higher order thinking skills of students in learning math skills. In addition, in the learning of mathematics is still very rare learning device specially designed to develop students' higher order thinking.
Based on the background above, some problems can be formulated as follows:

1. How will learning geometry-based SMP by using Van Hiele theory which is oriented in Higher Order Thinking Skills (HOTS)?

2. What steps learning theory by using Van Hiele which is oriented in Higher Order Thinking Skills (HOTS)?

II. EXPLANATION

Learning in Indonesia has been more centered on the teacher (teacher centered) and still use the approach/methods vary. Therefore, students tend to be less active in the learning process and learners are also not optimally solving mathematical problems and not meet aspects of high-level thinking. In mathematics higher level thinking skills are very important, because it is one of the goals of mathematics learning. It takes a learning device that can make learners active and have a high level thinking skills through the activities contained in the learning device.

Had a lot of learning activities that involve a variety of activities learners will make the learning of mathematics more meaningful. With these activities will help learners to reflect on learning experiences and create relationships, meaning, purpose and value of the experience. Thereby increasing the ability of high-level thinking learners. Hence the need for learning innovation accordance with the conditions of learners. Learning should be constructed so that it can spur students to be active and interested in a variety of math problems.

In accordance with the above description, to develop learning that can engage learners in learning activities and improve high-level thinking skills for students requires a suitable learning theory will be applied to the learners. One theory of learning which to improve high-level thinking skills in geometry is studied Van Hiele theory.

In studying Van Hiele theory there are a wide variety of student activities that can be implemented in the study of mathematics, especially geometry learning that aims to enrich, deepen and expand the capabilities of high-level thinking learners.

Mathematics learning by using learning implement learning activities in the Van Hiele theory is a study that is expected to enhance the ability of higher level thinking learners and can involve a wide variety of student activity in the learning process. Thus, in the end will create a more active learning and can increase high-level thinking skills for students.

Nitko and Brookhart (2011: 223) states that “a basic rule of assessment of higher order thinking skills is to use tasks that require the use of knowledge and skills in new or novel situations”. This means that the fundamental rule in measuring students' higher order thinking skills are premises give tasks using knowledge and skills with new situation. Brookhart (2010: 17) state that the general principle in assessing higher order thinking skills that consists of six aspects. The principle is as follows.

1. Define clearly and precisely what is being assessed
2. Items designed tests require students to use the knowledge and skills
3. Determine what will be taken as a result extent to which students have demonstrated knowledge and skills.
4. Provide something for students to think, usually in the form of an introductory text, visual, scenario, material resources, or a problem of some sort.
5. Using a new material for students.
6. Distinguish between the level of difficulty of thinking a lower level and higher level thinking, also control for each separately.

Assessment skills higher order thinking skills, according to Collins (2010) is an assessment rubric in the form of higher order thinking skills are developed locally rubric used to evaluate students' thinking skills in areas such as: application, analysis, evaluation, and creative. In addition, according to Thompson (2012) to measure the skills of higher order thinking skills for coverage of a class or ratings scale is based on the following three aspects:

1. Considering the sensitivity of the students in deciding whether the test items include low order thinking (LOT) or higher order thinking (HOT);
2. Using the special mathematics assessment framework with various categories of ratings;
3. Item test higher order thinking (HOT) is not confusing and used in real-world contexts (daily activity).

Furthermore, in compiling a matter of higher order thinking skills (HOTS) in this study is guided proposed by Principle NCTM Standards for Teaching Mathematics (2000) as follows.

   (1) Questions that help students work together to make sense of mathematics
   (2) Questions that help students Rely more on themselves to Determine Whether something is mathematically correct
   (3) Questions that help students learn to reason mathematically
   (4) Questions that help students learn to conjecture, invent, and solve problems
   (5) Questions that help students to connect mathematics, its ideas, and its applications.

This means that in formulating the question higher order thinking skills then: (1) questions to help students use reasoning to understand the math, (2) questions that help students more reliant on determining whether something completely automatically, (3) questions that help learning to mathematics reason, (4) questions that can help students learn to suspect, discovery, and solve problems, (5) questions that help students to connect HOTS with mathematics, ideas, and practices. Furthermore, Khan & Imanullah (2011) states that most of the questions that the low order includes knowledge, understanding, and applications.

Based on expert opinions and theories that have been described above it can be concluded higher order thinking assessment indicators used in this study guided by indicators blooms taxonomy revision by Anderson & Krathwohl (2001). Indicators are assessed adapted to the definition of higher order thinking skills (HOTS), namely: (1) critical thinking skills and (2) upon ability to think creatively.

Aspects of both the ability of higher order thinking skills at the top, ie critical thinking skills and creative thinking, described as follows.

1. Critical Thinking

Ennis (Costa, 1991: 80) states that "critical thinking is reasonable, reflective thinking is focused on Deciding what to believe or do". It means that critical thinking is thinking that is reasonable, reflective thinking that is focused on deciding what to believe or do. Aspects of critical thinking by Ennis (Costa, 1991: 80), namely: (1) clarification of the base, (2) support base, (3) In conclusion, (4) further clarification, (5) the strategy and tactics. The aspects above are used by researchers as a reference in the preparation of a matter of critical thinking.

2. Creative Thinking

Brookhart (2011: 124-125) states that creativity is defined as putting something in a new way, observing the other things were missing, to build something new, unusual or unconventional use imagery to keep working to make things interesting, and the like. From the above definition, it can be concluded assessing aspects of creative thinking, namely: (1) reasons, (2) create, (3) evaluate.

Higher Order Thinking Skills in Mathematics Learning in mathematics learning is one of the goals to be achieved are higher order thinking skills (HOTS). This requires skilled in mathematics teachers to provide questions that measure these aspects so that students become accustomed to work on the problems which measure skills HOTS.

REFERENCES