PROBLEM SOLVING AND MATHEMATICAL DISPOSITION BASED ON LEVEL OF GEOMETRY THINKING BY PBL VAN HIELE APPROACHES

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ABSTRACT

The purpose of this study was to analyze effectiveness of PBL model with Van Hiele approaches and to describe problem solving ability and mathematical disposition for each level of geometry thinking by PBL model with Van Hiele approaches. This study was a combination of qualitative and quantitative research. Model combination of this research was type of concurrent triangulation, which it was merging qualitative and quantitative methods in a balanced manner. Quantitative research sampling technique was simple random sampling which in this study taken a class experiment by PBL model with Van Hiele approaches and a control class by expository learning. Qualitative research subject selection techniques, was non-probability sampling, whereas the subjects based on levels of geometry thinking Van Hiele. PBL model with Van Hiele approaches effectived to problem solving ability and mathematical disposition. Problem solving ability and mathematical disposition for each level of geometry thinking Van Hiele were varies. Student on level 0 (visualization) can’t understand problem well. Students on level 1 (analysis) can understand problem but can’t plan well completion. Students on level 2 (deduction informal) can understand problem, execute plan well but can’t check results. Students on level 3 (deduction) can understand problem, implement plan well, and check results properly. Overall mathematical disposition each level of geometry thinking by PBL model with Van Hiele approaches included in the high category.

Keywords - level of geometry thinking, mathematical disposition, problem based learning (PBL), problem solving ability, Van Hiele approaches.

Introduction

Geometry was a branch of mathematics that it was very important learned because of applied in everyday life. Geometry had a better opportunity to be understood by the learner rather than the other branches of mathematics as it was containing geometric ideas which found in the neighborhood. However, problem solving ability of geometry between students can be different even though they were on same level of education. Van Hiele stated that increase the level one to the next level more depend on learning than aging (Usiskin, 1982).

According to Nur quoted by Sadiq (2009) stated that mathematics education Indonesia in general was still in conventional mathematical education where teachers taught mathematics to prove arguments directly. Students was less given opportunity to initiate a solution settlement itself, but only faced with the question of how to solve problems rather than to why such settlement. It was’nt in line with learning process in the educational unit based on SNP PP RI No. 19 (2005) which held in an interactiving, inspiring, funning, challenging, motivating students to participate actively and to provide enough space for innovative, creative, and independent in according to their talents, interests, physical, and psychological development of students. One of learning model’s in according to these principles was problem based learning (PBL). Meanwhile, differences levels of geometry thinking among studentss was needed Van Hiele approaches in learning geometry.

According Muhassanah and Riyadi, (2014) for each level of geometry thinking have different characteristics in solving geometry
problems. Therefore, analysis of problem-solving ability and mathematical disposition was needed for each level of geometry thinking Van Hiele by PBL models with Van Hiele approach. Based on description, the purpose of this study was to analyze effectiveness of the PBL models with Van Hiele approaches and describe problem solving ability and mathematical disposition for each level of geometry thinking by PBL model with Van Hiele approaches.

**Theoretical Review**

Geometry as a branch of mathematics which according to Usiskin (1987: 26-27) was (1) branch of mathematics that studied the visual patterns; (2) a branch of mathematics that connected mathematics to the physical world or the real world; (3) a way of presenting a phenomenon that didn't look or didn't physical; and (4) an example of a mathematical system. Level of geometry thinking according to Van Hiele theory (Crowley, 1987: 1) was level 0 (visualization), level 1 (analysis), level 2 (deduction informal), level 3 (deduction), and level 4 (rigor). PBL model with Van Hiele approaches was expected to address the differences in the level of geometry thinking.

Learning geometry by PBL model with Van Hiele approaches was expected to develop cognitive and affective students. One of cognitive domain was problem solving ability, while including affective domain was mathematical disposition. Problem solving ability by Anderson (2009) was a skill that involved the process of analyzing, interpreting, reasoning, predicting, evaluating, and reflecting. Steps to solve problem by Polya (1973) consisted of: understanding problem, planning solution, implementing plan, and examining process and results. While mathematically disposition according to NCTM (1989) was a tendency to think and act in a positive way in the learning mathematics.

Problem solving ability of students were taught by PBL model with Van Hiele approaches that was expected 75% of students to reach a minimum completeness criteria (KKM). Problem solving ability and mathematical disposition of students taught PBL model with Van Hiele approaches were also expected to be higher than the student whom are taught expository learning. According to Hudojo (2001: 21) that the affective domain can affect cognitive domains. Therefore, it was expected to positively influence mathematical disposition to problem solving ability of students whom taught PBL model with Van Hiele approaches.

**Research Methods**

This research was a combination of qualitative and quantitative research. The model in this study was a combination of concurrent triangulation. Concurrent triangulation is incorporating qualitative and quantitative research methods with balanced (Sugiyono: 2013: 499). The population was students of class X SMA N 9 Semarang academic year 2014/2015. Subject selection techniques of qualitative research was purposive sampling, whereas the subject was based on levels of geometry thinking Van Hiele. The sampling technique of quantitative research was simple random sampling, where sampling was done randomly. The research sample consisted of one experimental class and one control class. Students in the experimental class were taught by PBL models with Van Hiele approaches, while students in the control class were taught by expository learning.

Data collection techniques in this study consisted of: observation, test, scale psychology, and interview. Types of tests was used in this study, namely the Van Hiele geometry test (TGVH) and problem solving ability test (TKPM). TGVH performed twice: before and after the students made the learning process of geometry material in the experimental class, because according to
Usiskin (1982) increase in the level of thinking geometry from one level to the next level more dependent on learning than aging. TKPM only be done only once a time after the learning process in the experimental class and the control class. TKPM material in this study was a matter of geometry class X with problems in the form of a description. Psychology scale was used to measure mathematical disposition of students. The interview was designed to explore characteristics of problem solving ability and mathematical disposition students for each level of geometry thinking Van Hiele.

Data analysis was performed before until during in the field. Analysis done before in the field were validation of tools and instrument learning. Analysis during in the field was preparing systematically of quantitative and qualitative data obtained from observation, TGVH, TKPM, scale mathematical disposition, and interviews. Analysis of the quantitative data obtained from the result TKPM and scale mathematical disposition determined effectiveness of PBL model with Van Hiele approaches. Analysis of quantitative data used a test of completeness with z test, the average difference test with t test and regression analysis to determine the effect on the mathematical disposition to problem solving abilities. While analysis of qualitative data was done by reducing the data, presenting data, and drawing conclusions from the data collected and verifying this conclusion.

**Results and Discussion**

Based on the calculation results with the experimental class learning completeness t test right parties was gained $z_{count} = 1.854$ and $\alpha = 5\%$ was obtained $z_{0.45} = 1.64$. Because $z_{count} > z_{0.45}$ so Ho was rejected. Based on the results of this study was concluded that the problem solving ability of students were taught by PBL model with Van Hiele approaches that has reached a minimum completeness criteria of 70 to more than 75%. Based on the results of the calculation of the average difference TKPM by t test was obtained $t_{test} = 2.879$, while 5% of significance level and $df = 68$ was obtained $t_{table} = 1.669$, because $t_{test} > t_{table}$ then $H_0$ was rejected. Therefore, it can be concluded that the problem solving ability of students were taught by PBL model with Van Hiele approach higher than students were taught by expository learning. Based on the results of the calculation of the average difference scores mathematical disposition by $t_{test}$ was obtained $t_{test} = 2.738$, $df = 68$, while the 5% of significant level was obtained $t_{table} = 1.669$, because $t_{test} > t_{table}$ then $H_0$ was rejected. Therefore, it can be concluded that the score mathematical disposition of students were taught by PBL model with Van Hiele approaches higher than students were taught by expository learning. Based on the results of linearity test with SPSS significance value was 0% < 5% so that $H_0$ is rejected. This shows that the problem-solving ability (Y) can be predicted by mathematical disposition (variable X). Simple linear regression model between X and Y of student who are taught by PBL model with Van Hiele approaches was $Y = 39.782 + 0.457X$. Mathematical disposition positive affecting on problem-solving ability in students whom were being taught by PBL model with Van Hiele approaches reached 33.6%.

PBL model with Van Hiele approaches effective was applied mathematic learning in particular geometry material. There were because (1) the presentation of student whom were taught by PBL model with Van Hiele approaches already achieved more than 75%; (2) the average test score of problem-solving ability and mathematical disposition of student were taught by PBL model with Van Hiele approaches were higher than students whom were taught by expository learning; and (3) the mathematical disposition positive effect on problem-solving ability, so it was in line with the opinion of Mahmudi (2010) which
stated that the mathematical disposition to support the development of problem solving ability. Some experts also stated that PBL model effective in mathematics. Mariani, et al (2014) stated that the problem-based learning Mathematic Pop Up Book aided effectively to learning geometry. Padmavathy and Mareesh (2013) also stated that effective problem-based learning applied to the study of mathematics. Fatade (2012) also stated that the problem-based learning effectively applied to the study of mathematics. Abu and Abidin (2012) stated that learning geometry by applied Van Hiele theory effectively increase the students level of thinking Van Hiele. There were consistent with the results of Abdullah and Zakaria (2013) researches which stated that a significant increased students level of geometry thinking in the learning geometry.

In this study, TGVH was held twice in the experimental class. TVGH carried out before and after students of experiment class learned geometry materials. Figure 1 below was a grouping levels of geometry thinking Van Hiele based on the pretest and posttest in the experimental class.

Figure 1 Result of Geometry Van Hiele Test

Based on Figure 1, there were several students who changed levels of geometry thinking Van Hiele. Students on level 0 (visualization) decreased from the originally amounted to 25.7%, after learning down to 2.9%. Student on level 1 (analysis) also decreased from the initial 65.7% after learning down to 17.1%. Student on level 2 (deduction informal) increased from the initial 5.7% after learning up to 74.3%. Student on level 3 (deduction) also increased from the initial 2.9% after learning up to 5.7%. Nobody were level 4 (rigor) before and after studying.

Levels of geometry thinking Van Hiele lowest of student senior high school in grade X was level 0 (visualization). While levels of geometry thinking Van Hiele highest was level 3 (deduction). Burger and Shaughnessy (1986) also stated that level of geometry thinking for junior high students were level 2 (deduction informal) and most of students were level 0 (visualization). The statement was also supported by the opinion of Walle (1994) which stated that the majority of junior high school students were level 0 (visualization) to level 2 (deduction informal). Khoiriyah et al. (2013) stated that the results of research on the level of thinking geometry high school students based consists of level 0 (visualization), level 1 (analysis), and level 2 (deduction informal). It was consistenting with this study that student whom were at level 4 (rigor) to X-class senior high school has not been found.

Steps to solve problem by Polya consist of understanding problems, planning of problem solving, implementing plan of problem solving, and checking results. Problem solving ability of students were taught by PBL model with Van Hiele approaches at every level of thinking geometry have different characteristics. There were description for each level of geometry thinking to problem solving ability by PBL model with Van Hiele approaches.

(1) Students on level 0 (visualization) can identify elements that are known, but cannot mention the element in question.
Students on level 0 (visualization) cannot construct a mathematical model, it is seen from the inability to make a sketch based on the elements that are already known. The results are consistent with the opinion of Crowley (1987) which stated that students on level 0 (visualization) to make the shapes of geometry based on physical appearance as a whole. Therefore students of level 0 (visualization) cannot sketch geometry based solely on the description of the matter. In step plan, the students of level 0 (visualization) cannot plan properly to solve problems. Students on level 0 (visualization) cannot cite the formulas used to solve problems. This is because according to Fuys et al. (1988), students on level 0 (visualization) ability just identifying awake by its whole appearance, so that students of level 0 (visualization) cannot determine the settlement formula geometry problems.

(2) Students on level 1 (analysis) can identify the elements that are known and asked. Students on level 1 (analysis) also can develop mathematical models though not yet complete, it is seen from students on level 1 (analysis) ability to sketch geometry but not equipped with elements that are known. There were in line with the opinion of Crowley (1987) which stated that students on level 1 (analysis) can identify and draw waking given verbally or writing. Muhashanah and Riyadi (2014) also stated that students on level 1 (analysis) has been able to construct an image in accordance to characteristics given. In step plan, the students on level 1 (analysis) cannot plan solving problems properly. Students on level 1 (analysis) cannot cite the formulas used to resolve the problems appropriately. This is because according to Crowley (1987), the ability of students on level 0 (visualization) are still a class describing a structure in accordance to its properties and comparing based on the characteristics of its properties. In step implement plan, students on level 1 (analysis) cannot answer the question correctly as it cannot devise a plan to correct the problem solving. Therefore, students on level 1 (analysis) cannot write the final conclusions of problems solving. Students on level 1 (analysis) also cannot check the results.

(3) Students on level 2 (deduction informal) can identify the elements that are known and asked. Students on level 2 (deduction informal) also has to be able to construct a mathematical model completely, it is seen from the ability of students on level 2 (deduction informal) to sketch geometry that is equipped with elements that are known. In step implement the plan, the students level 2 (deduction informal) can answer problems correctly as it can devise a plan problem solving correctly. Therefore, students on level 2 (deduction informal) can write the final conclusions of solving problems. This is consistent with the opinion of Fuys et al. (1988) that student on level 2 (deduction informal) can give an informal argument that describe a conclusion, give conclusions using appropriate logic. However, student on level 2 (deduction informal) cannot check the result settlement of geometry problems. In step understand the problem, students on level 3 (deduction) can identify the elements that are known and asked. Students on level 3 (deduction) also has to be able to construct a mathematical model completely, it is seen from the ability of students on level 3 (deduction) sketch geometry that is equipped with elements that are known.

(4) Students on level 3 (deduction) have been able to plan problem solving properly and systematically. Students on level 3 (deduction) can also mention the formulas used to resolve the problems appropriately. In step implement the plan, students on level 3 (deduction) can answer problems correctly as it can devise a plan problem solving correctly. Therefore, students on level 3 (deduction) can write final conclusions of
problems solving. In step to check the results, students on level 3 (deduction) can check results. It was because Fuys et al. (1988) stated that students on level 3 (deduction) can prove relationship between theorem.

Mathematical disposition of students who are taught by PBL model with Van Hiele approaches including in the high category. There are description mathematical disposition of students based on the level of geometry thinking Van Hiele who are taught by PBL model with Van Hiele approaches.

1) Mathematical disposition of students on level 0 (visualization) included in the high category. All aspects of mathematical disposition exception aspect of self-confidence in learning mathematics and aspects of flexible in exploring mathematical ideas included in the high category. Confidence students of level 0 (visualization) in mathematics are including in medium category. While flexibility exploring mathematical ideas of students of level 0 (visualization) are included in the low category. This may be caused by the geometry ability of students of level 0 (visualization) are still low. Crowley (1987), Walle (1994), and Fuys et al. (1988) stated that students of level 0 (visualization) can only identify based on whole appearance.

2) Mathematical Disposition of students on level 1 (analysis) included in the high category. All aspects of mathematical disposition exception aspect of self-confidence in learning mathematics and aspects of flexible in exploring mathematical ideas included in the high category. Confidence in mathematics of students on level 1 (analysis), including in medium category. While the flexibility in exploring mathematical ideas of students on level 1 (analysis) included in the low category. This may be caused by the geometry ability of students on level 1 (analysis) are still low. Crowley (1987), Walle (1994), and Fuys et al. (1988) stated that learners level 1 (analysis) can only classify geometry based on its properties.

3) Mathematical disposition of students on level 2 (deduction informal) included in the high category. All aspects of mathematical disposition exception aspects of flexible in exploring mathematical ideas included in the high category. Flexibility in exploring mathematical ideas of students on level 2 (deduction informal) included in the category. Fuys et al. (1988) stated that learners level 2 (deduction informal) has been able to identify, use strategies and give a meaningful reason to solve problems.

4) Mathematical disposition of students on level 3 (deduction) included in the high category. All aspects of mathematical disposition exception aspects 7 to appreciate the role of mathematics included in the high category. Students of level 3 (deduction) has a very high desired to appreciate the role of mathematics. This can be due to already be at level 3 (deduction) have high capability of geometry. Fuys et al. (1988) stated that students on level 3 (deduction) was able to evidence creation and collection of simple axioms.

Conclusions and Recommendations

PBL models with Van Hiele approaches effectived to mathematic learning. Problem solving ability and mathematical disposition for each level of thinking geometry Van Hiele were varies. Students on level 0 (visualization) cannot understand problem well. Students on level 1 (analysis) can understand problem but cannot plan completion well. Students on level 2 (deduction informal) can understand problem, execute plan well but cannot check results. Student on level 3 (deduction) can understand problem, implement plan, and check results properly. Mathematical disposition of student were taught by PBL model with Van Hiele approaches overall for each level of geometry thinking including in the high category.
Application of Van Hiele approach needs to be applied to the study of geometry because it can increase the level of thinking geometry students. Students are grouped by level of thinking geometry with Van Hiele approaches. The limited ability of teachers to face the different levels of thinking geometry students are needed for development of instructional media that were able to develop students independence in learning geometry in accordance with the level of thinking. No one Student of senior high school secondary school has reached level 4 (rigor) therefore needed more research on higher education in order to find it level.

Bibliography


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