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Problem-Solving Ability and Self-Efficacy Based On Geometry Thinking Level In Van Hiele Learning

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Abstract

The objectives of this study are to test the effectiveness of van Hiele's learning of students; problem-solving ability and describe their problem-solving ability and self-efficacy based on the level of geometrical thinking. This research was a type of mixed quantitative and qualitative research. The study was conducted at MTs Asy-Syarifah in the 2015/2016 academic year. The research subjects were eighth grade students consisting of one experimental class with treatment using van Hiele learning and one control class. Hypothesis testing used a one-tailed proportion test and an average difference test. The results are obtained that van Hiele learning is effective in students' problem-solving ability. The average score of students who get van Hiele learning is higher than students who get expository learning. Students at level 2 (informal deduction) can reach all indicators of problem-solving. Students at level 2 can carry out the stages of problem-solving according to Polya's steps. Students at level 1 (Analysis), the students have not been able to carry out the completion plan appropriately. Students have difficulty in implementing a problem-solving plan. Students at level 0 (visualization) have not been able to plan properly. The results of the analysis of the three dimensions of students' initial self-efficacy show that students: (1) still have difficulties and try to avoid difficult tasks, (2) give up easily when facing difficulties.

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INTRODUCTION

To obtain a good quality mathematics education is the right of all students. Students deserve the opportunity and support to study mathematics in-depth and thorough understanding (NCTM, 2000: 1). Mathematics can be viewed from various perspectives and can enter all aspects of human life, from simple to complex (Das & Das, 2013: 1). Mathematics is an instrument to develop ways of thinking, abstract, its reasoning is deductive and concerning structured ideas whose relationships are arranged logically (Hudojo, 2003: 40-41). Mathematics is essentially a science in which formal and abstract deductive reasoning occurs, therefore, mathematics is often considered a difficult subject by some students. The characteristics of mathematics are unfortunately become the cause of students' perception that mathematics is a difficult subject (Yong & Kiong, 2012: 1). The notion of mathematics as a difficult subject is proven to affect mathematics learning achievement, one of them is on students' problem-solving ability (Das & Das, 2013: 1).

Geometry as a branch of mathematics is very important to study because geometry is widely applied in everyday life. Geometry has a greater chance of being understood by students than other branches of mathematics, because geometric objects containing geometric ideas, it can be found in the surrounding environment. Bobango (1993: 148) stated that "the objectives of learning geometry are expected that students can (1) gain confidence in their mathematical ability, (2) become good problem solvers, (3) communicate mathematically, and (4) make reason mathematically". However, understanding and solving geometry problems between one student and other students may be different even if the students are at the same level of education. Van Hiele stated that the improvement from one level to the next depends more on learning rather than the age or biological maturity (Usiskin, 1982: 4).

The level of geometrical thinking according to van Hiele's theory (Usiskin, 1982: 4) consists of five levels, the students are level 0 (visualization), level 1 (analysis), level 2 (informal deduction), level 3 (deduction), and level 4 (rigor). According to Crowley (1987), van Hiele's level of geometrical thinking has five characteristics, consisting of sequential, progressive, intrinsic and extrinsic, linguistic, and incompatible. According to Van Hiele as quoted by Yilmaz (2015: 130) "the level of geometric thinking, the average at the level of elementary school students at the first level. and the transition period from the second level"; at the level of junior high school students at the second level and the third level transition; High school students generally must be at the third and fourth level. Burger and Shaughnessy (1986) also stated that the level of thinking of junior high school students in learning geometry is highest at level 2 (informal deduction) and most are at level 0 (visualization).

Patkin (2014: 22) stated that teaching which consists of memorizing and repeating the same content without developing the required abilities and competencies does not improve the level of students' thinking. The teacher as a facilitator should construct student knowledge so that students understand the concepts not only by memorizing formulas. Siew, et al (2013: 2) stated that students need to develop and build schematics about two-dimensional geometric shapes and their properties before the students continue their geometry lessons at a higher level of education. The teacher must provide a learning experience that is appropriate to the level of student's thinking regarding geometric shapes. According to van Hieles, as quoted by Idris (2009: 98), students are assisted with proper experience instruction, passing through five levels, where students cannot reach one level of thinking without passing the previous level. The teacher in guiding students at each stage of learning, ensures students have understood at a certain stage before proceeding to the next stage. It is brief that throughout all stages of learning, the teacher has a variety of roles: the task of planning, directing students' attention to geometrically, and inviting students to a discussion using terms.

The difference in the level of geometrical thinking between students with one another becomes the basis of the need for van Hiele learning in learning geometry. Bobango (1993: 157) stated that learning that emphasizes the learning phase of van Hiele can help learning planning and provide satisfying results. Van Hiele (Usiskin, 1982: 4) also stated that if two students who were at different levels argued the students could not understand each other, therefore identification and grouping of geometrical thinking levels needed to be conducted so that students could be treated accordingly level of thinking. Harvard University United States research found that an individual's success is not determined solely by knowledge and technical skill (hard skills), but rather by the skill to manage themselves and others (soft skills) (Musclih, 2011: 84). The study revealed that success is only determined by about 20% of hard skills and 80% by soft skills. One soft skill related to mathematical problem-solving is self-efficacy. Self-efficacy refers to perceptions about the skill of individuals to organize and implement actions to display certain skills (Bandura, 2006: 307).

Based on observations of the results of the eighth-grade students of *MTs Asy-Syarifah Brumbung* in the academic year of 2014/2015 on geometry material, it is found a variety of students' ability to solve problems. Some students still experience difficulties in solving mathematical problems because their problem-solving ability is still lacking. Based on interviews with classroom teachers, the students state that geometry material is the most difficult material to be understood by students, especially the material to build flat side spaces. This is because learning geometry requires a fairly high abstraction ability, even though the level of thinking geometry between students varies. Furthermore, the teacher also stated that students' self-efficacy in learning mathematics is still low, many students feel unsure or confident about their abilities. It is often found in class, students who cam explain the results of their thinking in solving problem, however, the students do not dare to convey it.

METHOD

This type of research was a type of mix method research (quantitative and qualitative mixture). The combination model used in this study was the type of concurrent triangulation. Concurrent triangulation is a research method that combines qualitative and quantitative methods by mixing the two methods equally (Sugiyono: 2015: 499). The results of research with this method were more complete, valid, reliable, and objective because by using triangulation data collection techniques.

There were two stages of research where the research began with a preliminary study to identify problems in the field by conducting studies on data, interviews with teachers, and studies in the literature. In stage two, the researcher conducted quantitative and qualitative research together. The purpose of quantitative research was to find out the effectiveness of van Hiele's learning of problem-solving ability while qualitative research was to find out problem-solving ability and self-efficacy based on the level of geometrical thinking. The quantitative research used was a quasi-experimental design experimental study with a form of non-equivalent control group design in which the experimental class was treated while the learning control class was treated as usual, as the teacher taught regularly.

The population in this study were students of eighth grade of MTs Asy-Syarifah. From 4 classes, the students in eighth graders were chosen, 1 experimental class was chosen, it was given van Hiele learning, others hand, 1 control class was given conventional learning. In qualitative research, the research subjects used were only classes that receive van Hiele learning, it was the experimental class. The research subjects were selected from the experimental class where each level of geometrical thinking was sampled to analyze the problem-solving ability. Based on the results of van Hiele's geometry test, it was chosen students whose their the pre and post-test result were at level 0 (visualization) namely GVH1 subject, students at the level 0 on the pretest then at level 1 on post-test namely GVH2 subject, students at level 1 on the pretest and post-test namely GVH3 subjects, students at level 0 on pretest then level 2 post-test namely GVH4 subject, students at level 1 on pretest then level 2 on post-test namely GVH5 subject, students at level 2 on the pretest then at level 2 on the post-test namely GVH6 subject.

Sources of data in this study were the results of van Hiele's geometry test, the results of students' problem-solving ability test, the results of the self-efficacy questionnaire, the results sheet of the problem-solving ability interview and the students' self-efficacy interview. The research instrument consisted of test and non-test research instruments. The research instrument of the test was van Hiele's geometry test, a problem-solving ability test. Non-test research instrument, self-efficacy questionnaire, interview guidelines for students' problem-solving ability and self-efficacy interview guidelines. Each instrument was subjected to a feasibility analysis in which the instrument was tested for content validity and testing. The interview guide instrument was only conducted with content validation. Data analysis in quantitative research included the normality test, homogeneity test, completeness test, and average difference test. Qualitative data analysis followed the concept given by Milles & Huberman (2007), namely data reduction, data display (data presentation), and conclusions: drawing/verification.

RESULTS AND DISCUSSION

Based on the results of the calculation of mastery learning of the experimental class by using the test of the proportion of one-tailed test, it is obtained the average score of students in the experimental class is 79.1 with 35 students who passed individual completeness. This means that the percentage of students who fulfill individually on van Hiele learning is more than 75%. Therefore, the students' problem-solving ability who are treated van Hiele learning achieve mastery learning. The comparative test in this research is the average difference test of problem-solving ability. The average score of students in the class with van Hiele learning is 79.1 and the average score of students in the control class is 73.74. Furthermore, the average difference test of two independent samples is used to find out whether the problem-solving ability between the experimental classes is better than the control class students. Based on the results of calculations with the *t* test obtained t_{count} = 3.67 with a real level of 5%, *df* = 74, it is obtained t_{table} = 1.993, the problem-solving ability of experimental class students who are taught with van Hiele learning is higher than the control class.

Based on the results of the van Hiele geometry test in the experimental class, it is obtained the following results.

Table 1. The pre-tests results of van Hiele's geometry

Student Category	The number of students	Percentage (%)
Level 0	13	34.2
Level 1	19	50.0
Level 2	6	15.8
Total	38	100

Table 2. The post-tests results of van Hiele's geometry

Student Category	The number of students	Percentage (%)
Level 0	1	2.6
Level 1	12	31.6
Level 2	25	65.8
Total	38	100

Each level of students' geometrical thinking is chosen to be analyzed in-depth problem-solving ability and self-efficacy. The selection of students at pre-test and post-test level 0 (visualization) is the subject of GVH1. The selection of students at pre-test level 0 and post-test level 1 is GVH2 subjects. The selection of students at pre-test level and post-test level 1 is GVH3 subjects. The selection of students at pre-test level 0 and post-test level 2 is the subject of GVH4. The selection of students at pre-test level 1 and post-test level 2 is GVH5 subjects, and students at pre-test and post-level 2 are GVH6 subjects so that 6 students are selected for further analysis.

Students' problem-solving ability is assessed based on Polya's problem-solving steps. In the step of understanding the problem, subjects who obtain pre and post-test results at level 0 (visualization) is GVH1 subjects, students can identify the elements that are known and the elements in question. In the step of making a plan, the subjects of GVH1 cannot sketch a picture, because the students cannot sketch a picture so that the students cannot draw up a problem-solving plan correctly. In the steps of implementing the plan, GVH1 subjects cannot answer the problem correctly because students cannot draw up a problem-solving plan correctly. Therefore, it cannot write the conclusions of solving the problem. Subjects cannot check results. This is because according to Fuys et al. (1988), the ability of students at level 0 (visualization) is still merely identifying shapes based on their full appearance, so students at level 0 (visualization) have not been able to determine the geometry problem-solving formula.

GVH2 and GVH3 subjects are subjects who obtain the results of the post-test at level 1 (Analysis), in understanding the problem, students can identify the elements that are known and asked. In the step of making a plan, subjects GVH2 and GVH3 can also compile a mathematical model. This can be seen from the ability of GVH2 and GVH3 to sketch geometrical shapes and know what to look for first. This is because according to Muhassanah (2014), she stated that students in level 1 (analysis) can construct images in accordance with the characteristics given. So students at level 1 (analysis) can sketch geometrical shapes if the properties of the shapes are known. In carrying out the plans, GVH2 and GVH3, the students cannot mention the formulas used to solve the problem appropriately. In implementing the plan, GVH2 and GVH3 cannot answer the problem correctly because the students cannot draw up a problem-solving plan correctly. Therefore, GVH2 and GVH3 cannot write the conclusions of problem solving. GVH2 and GVH3 also cannot check results.

In the step of understanding the problem, students at level 2 (informal deduction), the students are subjects GVH4, GVH5, and GVH6, the students can identify the elements that are known and asked. In the step of implementing the plan, subjects GVH4, GVH5, and GVH6 have also been able to compile a complete mathematical model, this can be seen from the ability of GVH, GVH5, and GVH6 to make geometrical sketches that have been equipped with known elements. Students at level 2 (informal deduction) are one level higher than level 1 (analysis). Therefore, if students at level 1 (analysis) can sketch geometry according to their characteristics, students at level 2 (informal deduction) also have these abilities. GVH4, GVH5, and GVH6 can answer the problem correctly because the students can draw up a problem-solving plan correctly. Therefore, students at level 2 (informal deduction) can write the conclusions of problem-solving. This is in line with the opinion of Fuys et al. (1988) that students in level 2 (informal deduction) can provide informal arguments that are describing conclusions, giving reasons for conclusions using appropriate logic.

Self-efficacy on the magnitude dimension, the students already have the confidence to complete tasks or problems with low levels of difficulty but for medium to high levels of student confidence is still low. On the strength dimension, some students judge that the students can use all their ability to survive in their efforts to face the tasks and challenges. Although some students have tried, the students still fail in completing assignments and challenges, because students assume that the students are weak in learning mathematics and often fail on previous tests. When students are faced with an assignment and encounter difficulties students will ask a smarter friend. The results of the analysis of the three dimensions of students' initial self-efficacy show that students: (1) still have difficulties and try to avoid difficult tasks, (2) give up easily when facing difficulties, (3) have a low commitment to their achievement in learning mathematics, (4) previous failures prevented them from achieving better achievements, (5) have not been able to maximize efforts to correct failures the students are experienced, and (6) easily experience setbacks of confidence (not confident).

CONCLUSION

Based on the results of research and discussion, the author can conclude that van Hiele learning is effective towards students' problem-solving ability. Students with the level of thinking geometry 2 (informal deduction) can reach all indicators of problem-solving. Students with level 1 thinking (analysis) can already plan but still have difficulty in carrying out the planning. Students with a level of thinking 0 (visualization) have not been able to plan their problem-solving correctly. Students at the three levels of geometrical thinking show a significant improvement in the three dimensions of self-efficacy, especially in the dimensions of magnitude and strength, while for the dimension of generality, even though the students had improved but still had to be developed further by assigning more varied task.

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REFERENCES

Arikunto, S. 2007. Dasar-Dasar Evaluasi Pendidikan (Edisi Revisi). Jakarta: Penerbit Bumi Aksara.

Bandura, A. 1977. "Self-efficacy: Toward a Unifying Theory of Behavioral Change". Psychological Review.84: 191-215.

Bandura, A. & Adams, N.E. 1977. "Analysis of Self-Efficacy Theory of Behavioral Change". Cognitive Theraphy and Research. 1(4): 287-310.

Bandura. 2006. "Guide For Constructing Self-Efficacy Scales". Self Efficacy Beliefs of Adolescents, 1(4): 307-337.

Bobango, J.C. 1993. Geometry for All Student: Phase-Based Instruction. Dalam Cuevas (Eds). Reaching All Students With Mathematics. Virginia: The National Council of Teachers of Mathematics,Inc.

Burger, W.F. dan Shaughnessy, J.M.. 1986. Characterizing the van Hiele Levels of Development in Geometry. Journal for Research in Mathematics Education.Vol.17, No. 1, Hal.31-48.

Clowley, M. L. 1987. The van Hiele Model of the Development of Geometric Thought.Learning and Teaching Geometry, K-12, Yearbook of the Nasional Council of Teachers of Mathematic.Hal.1-16.

Das, R. & Das, G.C. 2013. "Math Anxiety: The Poor Problem Solving Factor in School Mathematics". International Journal of Scientific and Research

Fuys, D., Geddes, D., & Tischler, R. (2001). The van Hiele Models of Thingking in Geometry

Among Adolescents. Journal for Research in Mathematics Education. Monograph

Number 3. Reston VA: National Council of Teacher of Mathematics.

Hudojo, Herman. 2003. Pengembangan Kurikulum dan Pembelajaran Matematika. Malang: Jurusan Matematika FMIPA Universitas Negeri Malang.

Idris, Noraini. 2009. The Impact of Using Geometers' Sketchpad on Malaysian Students' Achievement and Van Hiele Geometric Thinking. Journal of Mathematics Education. Vol 2 (2):94-107.

Mc. Gregor, D. 2007. Developing Thinking Developing Learning. Poland: Open University Press.

Muhassanah, N. I. Sujadi, dan Riyadi. 2014. Analisis Keterampilan Geometri Siswa dalam Memecahkan Masalah Geometri Berdasarkan Tingkat Berpikir Van Hiele. Jurnal Elektronik Pembelajaran Matematika. Vol.2, No.1, hal 54 – 66.

NCTM. 2000. Principles and Standards for School Mathematics. USA: The National Council of Teacher Mathematics inc.

Patkin, D., dan Barkai¸ R. 2014. Geometric Thinking Levels of Pre- and

In-service Mathematics Teachers at Various Stages of Their Education. Educational Research Journal. Vol 29(1&2)

Polya.1973. How To Solve It, Second Edition. New Jersey: Princeton UniversityPress.

Siew, N., Chong, C., & Abdullah, M. 2013. Facilitating Students' Geometric Thinking Through Van Hiele's Phase-Based Learning Using Tangram.Journal of Social Sciences. 9 (3): 101-111

Sugiyono. 2011. Statistika Untuk Penelitian. Bandung: Penerbit Alfabeta.

Sugiyono. 2015. Metode Penelitian Kombinasi (Mixed Method). Bandung: Alfabeta.

Supardi, U.S. 2012. "Peran Berpikir Kreatif dalam Pembelajaran Matematika". Jurnal Formatif. 2(3): 248-262.

Supriadi. 2009. "Teori Belajar Matematika dengan Pendidikan Matematika di Indonesia". Jurnal Pendidikan Dasar UPI No. 12.

Suryabrata, S. 1984. Psikologi Pendidikan. Jakarta: Rajawali.

Suyitno, A. 2006. Dasar-dasar dan Proses Pembelajaran Matematika 1. Semarang : Jurusan Matematika FMIPA Unnes.

UNDP. 2013. Human Development Report. http://hdr.undp.org/en/content/table-1-human-development-index-and-its-components (diunduh 7 Desember 2015).

Usiskin, Z. 1982. Van Hiele Levels and Achievement in Secondary School Geometry. Chicago: University of Chicago.

Yilmas, G., & Koparan, T. 2015. The Effect of Designed Geometry Teaching Lesson to the Candidate Teachers' Van Hiele Geometric Thinking Level. Journal of Education and Training Studies. 4 (1): 129-141.

Yong, H. T. & Kiong, L.N.2012. "Metakognitive Aspect of Mathematics Problem Solving". Makalah. Seminar MARA University of Technology Malaysia.

Zimmerman, B. J. 2000. "Self-Efficacy: An Essential Motive to Learn". Contemporary Educational Psychology.Vol. 25, p. 82 - 91.

Zimmerman, M., Bescherer, C., & Spannagel, C. 2010. " A Questionnaire for Surveying Mathematics Self-Efficacy Expectation of

Future Teachers". Proceedings of CERME ,
University of Rzeszow.