UJMER 9 (2) 2020 170 – 178

Unnes Journal of Mathematics Education Research

http: //journal. unnes. ac. id/sju/index. php/ujmer

Analysis of Problem Solving on IDEAL Problem Solving Learning Based on Van Hiele Theory Assisted by Geogebra on Geometry

M. Faisal Abduh [1]✉, S.B. Waluya[2], Scolastika Mariani[2]

[1] SMK Amilia Paguyangan, Brebes, Indonesia
[2] Universitas Negeri Semarang, Indonesia

Article Info

Article History:
Received 28 June 2020
Approved 20 August 2020
Published 23 December 2020

Key words:
Geogebra;
IDEAL Problem Solving;
Problem Solving Ability; Geometry Thinking Level

Abstract

The objectives of this study are to analyze the effectiveness of the learning of IDEAL Problem Solving models based on Van Hiele theory assisted by Geogebra software and to describe students' problem solving ability at each level of geometrical thinking. This research was a type of qualitative and quantitative combination research. The combination model of this study was the type of concurrent triangulation, the combination of qualitative and quantitative methods in a balanced way. Quantitative research sampling technique was simple random sampling in which this study was taken in one experimental class and one control class. The technique of selecting qualitative research subjects was non-probability sampling, where the taking of subjects was based on the level of geometrical thinking. The conclusions are obtained (1) IDEAL Problem solving models Learning based on van Hiele theory assisted by Geogebra software is effective on students' problem solving ability. (2) The problem solving ability of each level of Van Hiele's geometry thinking is that students at level 1 (analysis), they can understand the problem but cannot plan their solution well. Level 2 students (informal deduction), they can understand problems, plan, implement plans well, but they cannot check results. Level 3 (deduction), the students can understand problems, plan, implement plans, and check results well.

✉Correspondence:
JL Raya Pagojengan-Paguyangan, No.100, Pagojengan, Paguyangan, 52276, Pagojengan, Paguyangan, Pekulen, Pagojengan, Kec. Paguyangan, Kabupaten Brebes, Jawa Tengah 52276, Indonesia
E-mail: gurufa@smkamiliapaguyangan.sch.id

P-ISSN 2252-6455
E-ISSN 2502-4507

INTRODUCTION

Learning is a process that delivers changes in student behavior from previous conditions. According to Sudjana as quoted by Syafni et al (2013: 15), learning is a process that is marked by changes in a person.

Mathematics is one of the basic and most important branches of science (Tai and Lin; 2015: 1480) so that it can shape quality human resources. This is reflected as quoted in (Hudojo, 2003: 40-41) that mathematics is an instrument to develop ways of thinking, abstract, its reasoning is deductive and concerning structured ideas which relationships are arranged logically.

The life that is always changing is characterized by the development of science and technology that leads to the improvement of complex problems faced by humans that demand the world of education, including mathematics education so that it always develops to answer the challenges in solving these problems. Furthermore, technology can be used as a means to develop mathematical competence, mathematics itself cannot be separated from Problem Solving (Bicer, Capraro, & Capraro, 2013; Ulya, Kartono, & Retnoningsih, 2014). Even since the 1980s Problem Solving has been considered the backbone of mathematics (Caballero, Blanco, & Guerrero, 2011).

Problem Solving ability is the ability to apply previously acquired knowledge to new unknown situations (Dewi, Ardana, & Sariyasa, 2019). The results of researcher's interviews with mathematics teacher of *SMK Ma'arif NU Tonjong* during teaching and learning process, some students have difficulty in solving problems with the type of Problem Solving in almost all the material taught, especially in the material which is application in daily life or real form, namely solid geometry.

The results of observations that are conducted by the researcher at *SMK Ma'arif NU Tonjong*, mathematics learning is carried out using a variety of methods and learning models. One of them is the question and answer method, the demonstration method, the training method, the conventional model, and so on. The results of research at John Hopkins University (Nur, 2005), student learning in team form is a traditional learning alternative that can be used as a permanent instrument for the class organization to get effective results. The use of group teaching strategies can develop Problem Solving ability well (Stiff et al, 1993; Esan, 2015). Slavin (2010) states that in cooperative learning, students will sit together in groups of four people to master the material.

Difficulties in learning mathematics faced by students because students only memorize concepts in learning mathematics and they are less able to use these concepts if they encounter problems (Trianto, 2007; Hastari, 2018). Learning models that meet these criteria are constructivist-based learning models such as IDEAL Problem Solving. Bransford and Stein (1993) introduce IDEAL Problem Solving as a model that can help to solve problems. IDEAL stands for I-Identify problems, D-Define goals, E-Explore possible strategies, A-anticipate outcomes and actions, L-look back and learn. Hence, in this study, the IDEAL Problem Solving learning model will also include the stages of student geometry thinking according to van Hiele above. The level of geometrical thinking according to Van Hiele's theory is divided into five levels. The five levels of geometry thinking according to van Hiele's theory are as follows (Zevenbergen, Dole, & Wright, 2004; Breyfogle & Courtney, 2010). Level 0 (visualization) is also known as the basic level. At this level students look at geometrical construction as a whole, getting to know geometric shapes based only on visual characteristics. But at this level, students have not been able to mention the properties of geometric shapes. Level 1 (analysis) is also known as the descriptive level. At this level, students can already understand the properties of geometric shapes. However, students at this level have not been able to find out the related relationship between a geometrical structure and other geometric shapes.

Level 2 (informal deduction) is known as an abstract, relational, theoretical, or related level. At this level, students can find out the related relationship between a geometrical shape and other geometric shapes. Students who belong to this stage, they have already understood the order of geometric shapes. At this stage, students also have begun to be able to conclude deductively, but they are still at an early stage, it means that they have not developed well. Level 3 (deduction) is known as the level of formal deduction. Students at this level can already understand deduction, which is deductive. Deductive drawing conclusions, namely drawing conclusions from special things. Students also understand the terms basic understanding, definitions, axioms, and theorems in geometry and they have begun to formally form proof. However, students at this stage cannot yet understand why something is presented in the form of axioms or propositions. Level 4 (rigor) is known as a dramatic level. At this level , students already understand how important the accuracy of the basic principles underlying a proof. Students also understand why something is used as axioms or propositions and they can analyze the consequences of manipulation of definitions and axioms. 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 and third levels; High school students generally must be at the third and fourth level.

Based on the researchers' observations of at *SMK Ma'arif NU Tonjong*, students are very enthusiastic when the learning process uses interactive media such as PowerPoint slides. Geogebra software is software with the basic idea of combining geometry, algebra, and calculus that can be used for learning and teaching at elementary, junior high, high school, and university levels (Hohenwarter, 2008; Zengin et al, 2012; Akhirni, 2015; Ekawati, 2016) Therefore, Geogebra software is chosen a media.

Based on this explanation, the objectives of this study are to analyze the effectiveness of learning the IDEAL Problem Solving model based on van Hiele's theory assisted by Geogebra software and to describe the students' Problem Solving ability at each level of geometry thinking.

METHODS

This research was a combination of qualitative and quantitative research. The combination model used in this study was the type of concurrent triangulation that combined qualitative and quantitative methods by mixing the two methods equally (Sugiyono: 2013: 499). The population of this research was the students of XI grade of *SMK Maarif NU Tonjong* in the academic year of 2018/2019. The subject selection technique in qualitative research was non-probability sampling, it was by taking the subjects where each research object taken did not have the same opportunity to be the subject of research. The type of non-probability sampling used was purposive sampling, where subjects were taken based on Van Hiele's level of geometrical thinking. The sampling technique in quantitative research was simple random sampling which was a random sampling technique. The research sample consisted of one experimental class and one control class. The experimental class with the learning model IDEAL Problem Solving based on van Hiele theory was assisted by Geogebra software, while the control class was treated with conventional learning.

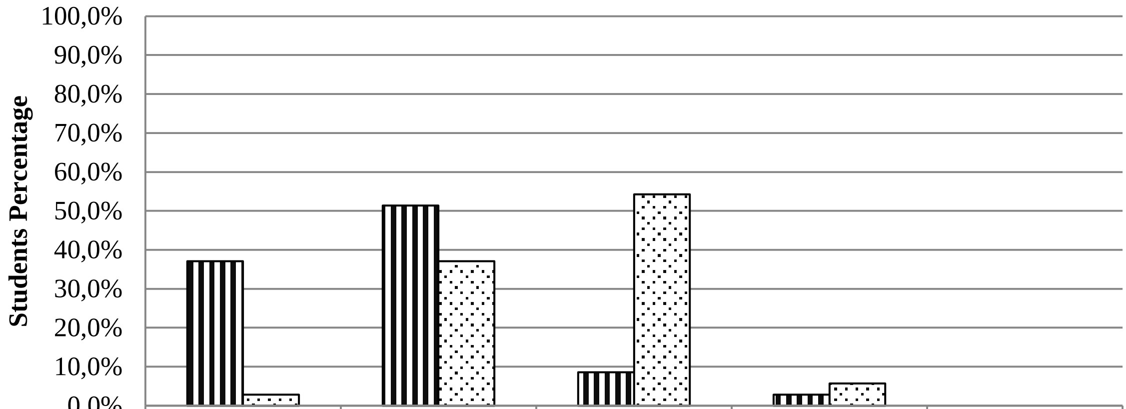
Data collection techniques in this study consisted of observation, tests, psychology scales, and interviews. In this study there were two types of tests, they are the Van Hiele geometry test (VHGT) and the Problem Solving ability test (PSST). VHGT was conducted twice, before and after the experimental class students carried out the learning process on geometry material. This was because according to Usiskin (1982) the increase in the level of thinking geometry from one level to the next depends more on learning than the age maturity. PSST was only conducted only once after the learning process in the experimental class and the control class. The PSST material in this study was geometry material for XI grade with questions in the form of essay. The psychological scale in this study was used to measure the response to the use of Geogebra software. Interviews were designed to explore the characteristics of Problem Solving ability and the response to the use of Geogebra software.

Data analysis was carried out during the phase before in the field until the analysis phase while in the field. Analysis before doing in the field was conducted by validating the research instruments. Analysis during the field was systematically compiling quantitative and qualitative data obtained from observations, VHGT, PSST, and interviews. Quantitative data analysis, it was obtained from PSST data and the scale of the use of Geogebra software to determine the effectiveness of IDEAL Problem Solving learning model based on van Hiele theory assisted by Geogebra software consisting of completeness test with *z*-test, average difference test with *t*-test, and proportion test. While qualitative data analysis was conducted by reducing data, presenting data, and drawing conclusions from data that has been collected and verifying these conclusions.

RESULTS AND DISCUSSION

Based on the calculation results of individual learning completeness using the average test of the one side obtained t_{table} = 1.69 and t_{count}=8.44, that $t_{count} \geq t_{table}$, it means that H_0 is rejected or the average of the Problem Solving ability of students with IDEAL Problem Solving based on van Hiele theory assisted by Geogebra software exceeds 74.5. Based on the results of classical learning completeness calculations using the right-side proportion test obtained z_{table} = 1.64 and z_{count} = 1.91. that $z_{count} \geq z_{table}$, it means that H_0 is rejected or more than 74.5% of all students with the learning of IDEAL Problem Solving models based on van Hiele theory assisted by Geogebra software can achieve completeness at PSST. Based on the calculation results of the test of the average difference in PSST results between the experimental class and the control class, obtained t_{count} = 1.691 and t_{table} = 1.669. Because $t_{count} > t_{table}$, H_0 is rejected. Therefore, it can be concluded that the students' Problem Solving ability with the learning of IDEAL Problem Solving models based on van Hiele theory assisted by Geogebra software is higher than students with conventional learning. The learning of IDEAL Problem Solving models based on van Hiele theory assisted by Geogebra software is effective for students' Problem Solving ability. This is because (1) the percentage of students with IDEAL Problem Solving Learning based on Van Hiele theory assisted by Geogreen software has reached completeness, which is 70 more than 75% and (2) the average results of tests of Problem Solving ability of IDEAL Learning Problem Solving based on Van Hiele theory assisted by Geogebra software is higher than students with conventional learning..

In this study, VHGT is conducted twice in the experimental class. VHGT is conducted before and after the experimental class students get the material regarding geometry material. Figure 1 below is a grouping of Van Hiele geometry thinking levels based on the results of the pretest and post-test in the experimental class.



	Level 0 (Visualization)	Level 1 (Analysis)	Level 2 (Informal Deduction)	Level 3 (Deduction)	Level 4 (Rigor)
Pre-test	37,14%	51,43%	8,57%	2,86%	0,00%
Post-test	2,86%	37,14%	54,29%	5,71%	0,00%

Figure 1. Van Hiele Geometry Test Results

Based on Figure 1, there are some students have experienced changes in Van Hiele's level of geometry thinking. Students who are at level 0 (visualization) decrease after learning from the original 37.14% to 2.86%. Students who are at level 1 (analysis) also experienced a decrease after learning, from initially at 51.43% to 37.14%. Students who are at level 2 (informal deduction) experienced an increase after learning, from initially at 8.57% to 54.29%. Students who are at level 3 (deduction) also experienced an increase after learning, from initially at 2.86% to 5.71%. No one student who is at level 4 (rigor) before or after learning.

Table 1. Problem Solving Ability at each level of Van Hiele Geometry Thinking

Problem Solving Indicators	Level 0 (Visualization)	Level 1 (Analysis)	Level 2 (Informal Deduction)	Level 3 (Deduction)
Understand the Problem	Students can mention information that is known in accordance with the problem Students cannot sketch according to the information provided. Students cannot mention the problem being asked.	Students can mention information that is known in accordance with the problem. Students can sketch problems but it is still incomplete. Students can mention the problem being asked.	Students can mention information that is known in accordance with the problem. Students can sketch according to the information provided Students can mention the problem being asked.	Students can mention information that is known in accordance with the problem. Students can sketch according to the information provided. Students can mention the problem being asked.
Make a Plan	Students cannot develop Problem Solving plans correctly. Students cannot mention the formula that will be used to solve problems.	Students develop incorrect and incomplete Problem Solving plans. Students mention the wrong formula in solving problems.	Students can arrange Problem Solving plans correctly but not systematically. Students can write the correct formula to solve the problem but it is still incomplete.	Students can arrange Problem Solving plans correctly and systematically. Students can mention the formula to be used correctly.
Carry out the plan	Students cannot answer the problem correctly because they cannot draw up a Problem Solving plan correctly Students cannot write the conclusions of solving problems.	Students cannot answer the problem correctly because the Problem Solving plan that is prepared is still not right Students cannot write the conclusions of solving the problem.	Students can answer the problem correctly because they can draw up a Problem Solving plan correctly even if it is not systematic. Students can write the conclusions of solving the problem.	Students can answer problems correctly and systematically because they can arrange Problem Solving plans correctly and completely. Students can write the conclusions of solving the problem.
Check the Results	Students cannot recheck the results of their work.	Students cannot recheck the results of their work.	Students cannot recheck the results of their work.	Students cannot recheck the results of their work.

The lowest level of Van Hiele geometry thinking in XI grade of Vocational High School students is level 0 (visualization). Whereas the highest level of Van Hiele geometry thinking in grade XI grade of Vocational High School students is level 3 (informal deduction). Some previous studies on the level of thinking of students in geometry include Muhassanah and Riyadi (2014) state that the highest level of Van Hiele thinking that can be achieved by students of VIII grade of junior high school (middle school) is level 2 (informal deduction). Burger and Shaughnessy (1986) also state 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). This statement is also supported by the opinion of Walle (1994) which states that the majority of junior high school students are between level 0 (visualization) to level 2 (informal deduction). Khoiriyah et al. (2013) state that the results of research on the level of thinking of senior high school students based on Van Hiele's theory on the three dimensional material in terms of the FD and FI cognitive styles consisted of level 0 (visualization), level 1 (analysis), and level 2 (informal deduction). This is in line with this study that students who are at level 4 (rigor) for the vocational education level XI have not yet been found.

In this study, the grouping the level of Van Hiele geometry thinking that will be analyzed is the ability of Problem Solving based on the results of the pre-test and post-test. Students who are included in level 0 (visualization) are GVH 1 subjects. Students who are included in level 1 (analysis) are GVH 2 subjects and GVH subjects 3. Students who are included in level 2 (deduction informal) are GVH 4 subjects, GVH 5 subjects, and GVH subjects 6. Students who are included in level 3 (deduction) are GVH 7 subjects and GVH 8 subjects.

Table 1 is the result of research of Problem Solving ability based on Polya's step at each level of Van Hiele's thinking geometry. Students’ Problem Solving ability (visualization) at level 0 are as follows: (1) students can mention information that is known in accordance with the problem; (2) Students cannot sketch according to the information provided; (3) students cannot mention the problem being asked; (4) students cannot draw up a Problem Solving plan correctly; (5) students cannot mention the formula that will be used to solve the problem; (6) students cannot answer the problem correctly because they cannot draw up a Problem Solving plan correctly; (7) students cannot write the conclusions of problem solving; and (8) students cannot recheck the results of their work.

Students’ Problem Solving ability at Level 1 (analysis) are as follows: (1) students can mention information that is known in accordance with the problem; (2) students can sketch problems but it is still incomplete; (3) students can mention the problem being asked; (4) students draw up a Problem Solving plan that is less precise and incomplete; (5) students mention the wrong formula in solving problems; (6) students cannot answer the problem correctly because the Problem Solving plan that is prepared it is still wrong; (7) students cannot write the conclusions of solving the problem; and (8) students cannot recheck the results of their work.

Students’ Problem Solving ability at Level 2 (informal deduction) are as follows: (1) students can mention information that is known in accordance with the problem; (2) students can sketch according to the information provided; (3) students can mention the problem being asked; (4) students can develop Problem Solving plans correctly but not systematically; (5) students can write the correct formula to solve the problem but still not complete; (6) students can answer the problem correctly because they can draw up a Problem Solving plan correctly even if it is not systematic; (7) students can write the conclusions of solving the problem; and (8) students cannot recheck the results of their work. Students’ Problem Solving ability at Level 2 (deduction) are as follows: (1) students can mention information that is known in accordance with the problem; (2) students can sketch according to the information provided; (3) students can mention the problem being asked; (4) students can develop Problem Solving plans correctly and systematically; (5) students can mention the formula to be used correctly; (6) students can answer problems correctly and systematically because they can arrange Problem Solving plans correctly and completely; (7) students can write the conclusions of solving the problem; and (8) students can recheck the results of their work.

CONCLUSION

Based on the results of this study, the following conclusions are obtained, (1) IDEAL Problem Solving models Learning based on van Hiele theory assisted by Geogebra software is effective on students' Problem Solving ability. (2) The Problem Solving ability of each level of Van Hiele's geometry thinking is that students at level 1 (analysis), they can understand the problem but cannot plan their solution well. Level 2 students (informal deduction), they can understand problems, plan, implement plans well, but they cannot check results. Level 3 (deduction), the students can understand problems, plan, implement plans, and check results well.

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