Teacher and students response to learning devices based on van hiele theory

S Wiska¹, E Musdi¹* and Y Yerizon¹

¹Mathematics Department, Universitas Negeri Padang, Padang, Indonesia

*corresponding author: win_musdi@yahoo.co.id

Abstract. Critical thinking is one of the higher order thinking ability that needs to be developed in the 21st century. In fact, the students’ critical thinking ability are still low. In learning geometry students are still dependent on the teacher in receiving information, the media are inadequate in learning geometry so that students have not been trained to solve geometry problems with critical thinking. Thus a geometrical learning devices was made based on the van hiele theory. Before using the geometry learning devices, it is validated first with the experts, asking the teacher's response, and student responses through questionnaires and interviews. The subjects of this study were class VIII students of SMP 13 Padang. The results showed that the response of teachers and students showed the geometry learning devices is practical criteria.

1. Introduction

Geometry is one of the materials that have an important role in mathematics. Studying geometry can help students to train their thinking ability and solve problems ability in daily life, to practice their mathematical critical thinking ability, and to prepare themselves to take further studies and obtain professional work later on [1]–[3]. In addition, geometry is also associated with many other fields in mathematics such as, measurement, algebra, calculus, and trigonometry. It is used every day by architects, computer experts, engineers, geologists, physicists, land surveyors and many other professionals [4], [5]. Thus, a good understanding of geometry is needed.

In Indonesia, the importance of geometry is seen in the placement of geometry as a learning material, which has a relatively large proportion in the curriculum. At the junior high school level, about 40% of the learning material taught is about geometry. For the eighth grade students, 5 of 10 subjects taught, are in the form of geometry learning material.

But in reality, the understanding of mathematics in geometry of junior high school students are still low. It can be seen from the results of the TIMSS (Trends of the International Mathematics and Science Study) in geometry from several years ago which were attended by eighth grade students in various countries, as shown in Table 1.
Table 1. International Geometry Score and Indonesia Geometry Ranking at TIMSS

| Aspect                | TIMMS       |
|----------------------|-------------|
|                      | Year 2003  | Year 2007 | Year 2011 |
| International average score | 46  | 32  | 58  |
| Indonesia’s Score    | 31  | 19  | 27  |
| Indonesia’s Ranking  | 37  | 37  | 39  |
| Participation Country| 46  | 49  | 42  |

Source: [6]-[8]

From Table 1 it can be seen that Indonesia’s score in geometry is below the international average score. In addition, Indonesia's ranking in geometry is also in the range of 15 countries with the lowest score. The low level of students’ absorption in the geometry is also found in Junior High School of Serang District and Junior High School 2 Ambarawa, [9], [10]. Thus critical thinking skills are needed by students for a better understanding of geometry.

However, after some observations in several schools in the city of Padang, it is found that the mathematical thinking ability of eighth grade students on geometry is still low. Those observations are carried out at Junior High School 30 Padang and Junior High School 13 Padang. It can be seen that the learning activities that are taken place in schools still do not facilitate or optimize the students' mathematical critical thinking abilities. Students are still not familiar with non-routine questions. There is often a misunderstanding between what is conveyed by the teacher and what is received by the students. Because of the difference in perception, students have difficulty working on questions that contain mathematical critical thinking abilities.

In addition, many students did not like geometry because it was difficult. Based on interviews with several students, the difficulty of understanding geometry occurs because they have difficulty in thinking of abstract forms, analyzing the properties of observed geometric objects, and presenting geometric objects in the form of images. Moreover, students also feel less interested in learning mathematics. So that, students’ understanding of geometry are low and need to be improve for solving the problem and thinking critically.

The difficulty of students in understanding non-routine questions shows that the learning process in the classroom has not been implemented optimally. Based on the results of interviews with mathematics teachers, one of the obstacles faced is the inadequacy of learning devices available to develop students' mathematical critical thinking abilities. The teacher acknowledges that using student worksheet can help students' thinking abilities in the learning process and it was not easy to make learning devices. Based on [11] Student Worksheet (SW) contains tasks that must be done by students, usually in the form of instructions, steps to complete a task. Because of that, only teacher used books.

The results of the study that could overcome students' learning difficulties in geometry were van Hiele research in 1959. In his theory, van Hiele explained that the combination of time, teaching material, and learning methods, is an element that could improve students' thinking skills into a higher level [12]. In van Hiele theory [13] there are five stages of geometrical thinking.

Geometry learning based on van Hiele theory will be more optimal if the teacher designs learning devices, namely SW. SW designed based on van Hiele theory can be used by students in solving geometry problems. In addition, SW is designed to help students understand geometry according to the level of thinking they have. SW is also equipped with quiz questions that contain indicators of critical thinking skills.

SW based on van Hiele theory is expected to improve students' critical thinking abilities. Indicators of mathematical critical thinking abilities that will be developed are identifying, evaluating, connecting,
and drawing conclusions. Every stage of van Hiele theory learning will encourage students to practice their mathematical critical thinking abilities. Based on this description, the authors conducted a study of the practicality of learning devices based on van Hiele theory to improve the mathematical critical thinking abilities of eighth grade students of Junior High School 13 Padang.

2. Methods
Some of the stages carried out in this study are designing geometry learning devices, validating geometry learning devices, knowing teacher responses, and knowing students' responses.

2.1. Designing Geometry Learning devices
At this stage geometry learning devices are designed based on van Hiele theory for eighth grade students of Junior High School based on the results of preliminary research. Activities carried out at this stage are designing learning devices according to the guidelines. The Lesson Plan (LP) was prepared based on [14]. Learning devices designed in the form of LP and SW. LP is a plan of learning activities to achieve a basic competency [14]. SW was compiled based on the Guidelines for the Development of Teaching Materials issued by the revised 2013 curriculum in 2017 with regard to the feasibility aspects of content, language, presentation, and graphics. The LP and SW were developed based on Van Hiele's theory. The results of the design at this stage produce prototype 1 learning devices. In prototype 1, self-evaluation and expert review are conducted.

2.2. Validating geometry learning devices based on the van hiele theory
LP and SW validation was consulted and discussed with three mathematics lecturers, one language lecturer, and one education technology lecturer. Critics, input, and suggestions from the validators will be material to revise the Prototype 1 learning tool based on the Van Hiele theory developed. The aspect assessed in the validation of the LP is the completeness of the components in the SW. While the aspects assessed in the SW validation are the aspects of content, language, presentation, and graphics. The instrument used is the LP validation sheet and SW validation sheet.

2.3. Knowing Teacher’s Response
After being validated then geometry learning devices were tried out in small groups then continued to large groups. Learning activities carried out in accordance with the stages of learning van hiele theory. The instruments used to see the teacher's response to learning devices are through questionnaires and interview guidelines.

2.4. Knowing Student’s Response
Students use SW geometry based on Van hiele theory during the assessment process. After using SW students are asked for their opinions. The instrument used to see students' responses to learning devices is through questionnaires.

The indicators assessed in the lesson plan are the implementation of learning activities and the use of time. While the indicators assessed in SW are the implementation of learning geometry using the Van Hiele theory based SW, the time needed to work on the Van Hiele theory based SW, and the ease of using SW based on Van hiele theory.

Data collection techniques by analyzing interview data and questionnaire data analysis. Data analysis techniques for the questionnaire used a Likert scale. Likert scale is arranged in a positive category, so the positive statement score according to Arikunto states, score 4 for strongly agree statement, score 3 for agree statement, score 2 for disagree statement, score 1 for statement is very not agree [15]. While the interview data were analyzed using descriptive techniques through three stages namely reducing data, presenting data, and drawing conclusions. The practicality of learning devices based on Van Hiele theory if the results of the practical assessment are on average more than or equal to 75 [16].
3. Result and Discussion

Learning geometry based on Van Hiele theory trains the process of thinking levels of students. In addition, learning geometry is also supported by several stages of learning to benefit students in the thought process and improve their ability to think mathematics critically. In the learning process, students are given the opportunity to exchange ideas with group friends so they can learn more independently. Ebiendele Ebosele Peter [17] also shows the results of research which states that learning involving students actively in project-based or collaborative activities can encourage the development of students' critical thinking. This shows that learning devices based on Van Hiele theory can help students to develop critical thinking skills in geometry. This is also supported by teacher responses and positive student responses in the development of van hiele's theory-based geometry learning devices. Teacher and student responses regarding the developed geometry learning tool were seen from the results of the teacher's response questionnaire, student response questionnaire, and interview results. The following are the results of the questionnaire responses of teachers and students through questionnaires in Table 2 and Table 3.

### Table 2. Questionnaire Results of Student Responses to SW Based on Van Hiele Theory

| No. | Rated Aspects | Mean | Percentage (%) | Category      |
|-----|---------------|------|----------------|---------------|
| 1.  | Presentation | 3,75 | 93,75          | Very Practical|
| 2.  | Use          | 3,45 | 86,36          | Very Practical|
| 3.  | Legibility   | 3,5  | 87,5           | Very Practical|
| 4.  | Time         | 3    | 75             | Practical     |

**Average Practicality** 3,425 (85,65) Very Practical

### Table 3. Questionnaire Results of Student Responses to SW Based on Van Hiele Theory

| No. | Rated Aspects | Mean | Percentage | Category |
|-----|---------------|------|------------|----------|
| 1.  | Presentation | 3,15 | 78,83      | Practical|
| 2.  | Use          | 3,10 | 77,61      | Practical|
| 3.  | Legibility   | 3,23 | 80,83      | Practical|
| 4.  | Time         | 3,16 | 79,16      | Practical|

**Average Practicality** 3,16 (79,10) Practical

Based on the results of the questionnaire, information was obtained that the aspects of presentation, use, readability, and time is practical criteria. In the results of the teacher's response questionnaire, the aspect of presentation was higher in percentage than the other aspects. While the results of the questionnaire, responses of students aspects of legibility are higher than the other aspects. The results of interviews with teachers revealed that lesson plans were enough to help teachers learn geometry and develop students' critical thinking skills. Besides, the stages of learning theory Van Hiele can help students with different abilities. This is supported by research conducted by Muslims [3] which states that with van hiele learning can develop critical thinking abilities. Based on the results of the research that has been done [18]–[23] states that learning devices based on the learning theory stage of Van Hiele can improve critical thinking skills, understand geometric concepts of students, develop students' character, achievement, learning motivation, as well as the geometry ability of students.

4. Conclusion

Based on the analysis of the results, learning geometry based on Van Hiele theory is practical in practicing geometry abilities and mathematical critical thinking abilities of eighth grade students of Junior High School 13 Padang.
References

[1] Jupri A 2018 Using the van hiele theory to analyze primary school teachers’ written work on geometrical proof problems *J. Phys.: Conf. Ser* **1013**

[2] Fitriyani H, Widodo SA Adi and Hendroanto A 2018 Students’ geometric thinking based on van hiele’s theory *Infinity* **7** 55-60

[3] Muslim A 2017 Proses berpikir kritis siswa pada level deduksi informal siswa van hiele *Prosiding Si MaNis* **16** 86-94

[4] Abdullah AH and Zakaria E 2013 The effect of van hiele’s phases of learning geometry on student’s degree of acquisition of van hiele level *Procedia - Social and Behavioral Sciences*, **102** 251–66

[5] Meng, CC 2009 Enhancing students' geometric thinking through phase-based instruction using geometry’s sketchpad: a case study *Jurnal Pendidik dan Pendidikan* **24** 89–107

[6] Martin MO, Gonzalez EJ, and Chrostowski SJ 2004 TIMSS 2003 International Mathematics and Science Report

[7] Mullis IVS, Martin MO and Foy P 2004 TIMSS 2007 International Mathematics

[8] Mullis, Martin MO, Foy P and Arora A 2012 Timss 2011 International Results in Mathematics

[9] Marlina M 2013 Pengembangan perangkat pembelajaran geometri smp dengan strategi pembelajaran kolaboratif *Jurnal Pendidikan Matematika* **8** 146-59

[10] Lestariyani S, Novisita R, Yuniarta, Hasti TN 2014 Identifikasi tahap berpikir geometri siswa smp negeri 2 ambarawa berdasarkan teori van hiele *Satya Widya* **30** 96-103

[11] Depdiknas 2008 *Panduan Pengembangan Bahan Ajar* (Jakarta: Direktorat Jenderal Manajemen Pendidikan Dasar dan Menengah)

[12] Safrina 2018 Peningkatan kemampuan pemecahan masalah geometri melalui pembelajaran kooperatif berbasis teori van hiele *J. Peluang* **6** 52-7

[13] Breyfogle M, Lynch CM 2010 Van hiele revisited mathematics teaching in the middle school **16** 232-8

[14] Permendikbud 2016 *Lampiran Peraturan Menteri Pendidikan dan Kebudayaan Republik Indonesia Nomor 22 Tahun 2016 tentang Standar Proses Pendidikan Dasar Dan Menengah* (Jakarta: BSNP)

[15] Arikunto S 2008 *Dasar-dasar Evaluasi Pendidikan* (Jakarta: Bumi Aksara)

[16] Purwanto N 2012 *Prinsip-prinsip dan Teknik Evaluasi Pengajaran* (Bandung: Remaja Rosdakarya)

[17] Peter EE 2012 Critical thinking: essence for teaching mathematics and mathematics problem solving skills *Department of Mathematics and Computer Science Research* **5** 39-43

[18] Primasaty N and Jatmiko 2018 Pengembangan multimedia geometri berbasis teori berpikir van hiele guna meningkatkan kemampuan berpikir kritis siswa kelas v *Jurnal Ilmiah Pendidikan Matematika* **3**

[19] Puspitasari DI 2016 Pengembangan bahan ajar berbasis tahap berpikir van hiele untuk meningkatkan pemahaman konsep geometri *Thesis*

[20] Israil 2016 penerapan teori belajar van hiele pada materi segiempat untuk meningkatkan kualitas dan hasil belajar siswa kelas ix smp negeri 8 donggo satu atap kabupaten bima tahun pelajaran 2014/2015 *Jurnal Pendidikan Mandala* **1** 194-9

[21] Kamaruddin R, Rosida V, Muchsin and Busyrah 2017 Pengembangan perangkat pembelajaran matematika materi geometri berbasis teori belajar van hiele untuk meningkatkan karakter siswa kelas vii smp muhammadiyah bungoro *Edumatica* **7**

[22] Semadiarta, IKS 2012 Pengembangan media pembelajaran berbasis komputer dengan microsoft excel yang berorientasi teori van hiele pada bahasan trigonometri kelas x sma untuk meningkatkan prestasi dan motivasi belajar matematika siswa *Thesis*

[23] Ikhsan M 2012 Pengembangan model pembelajaran berbasis teori van hieleuntuk meningkatkan kemampuan geometri siswa smp di kota bandar aceh” *Jurnal Pengajaran MIPA* **17** 164-72