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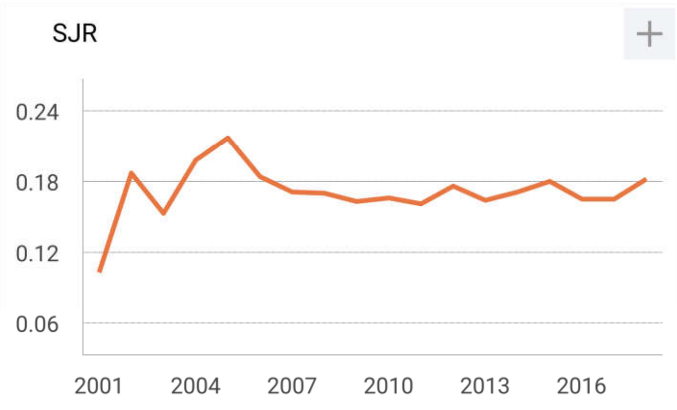

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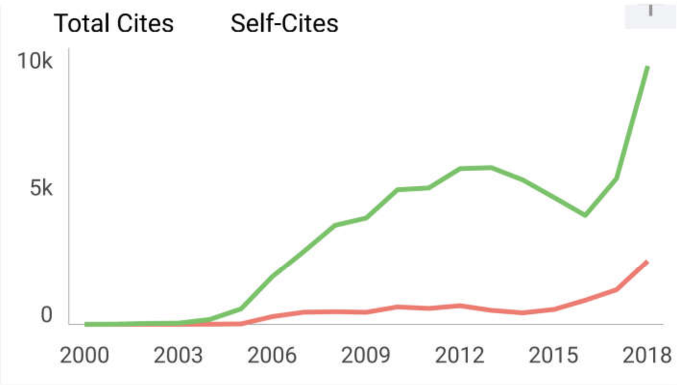
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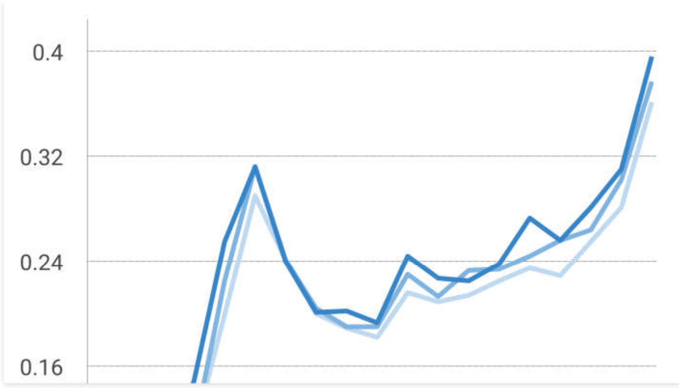
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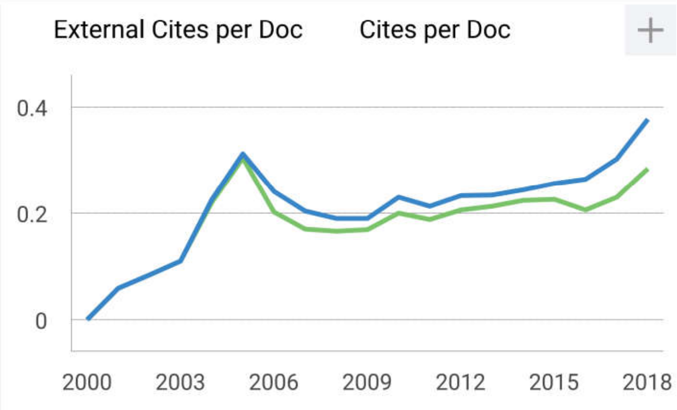
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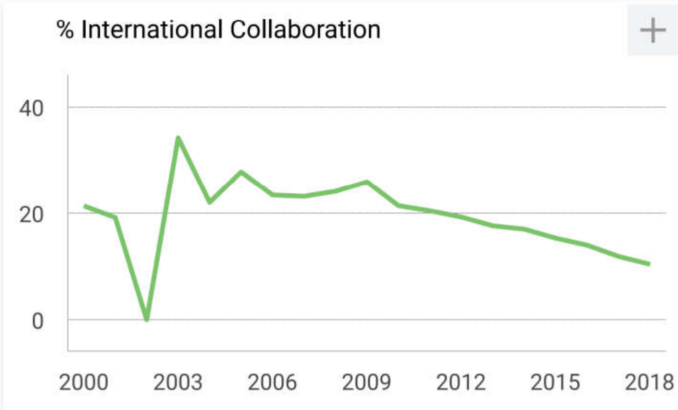
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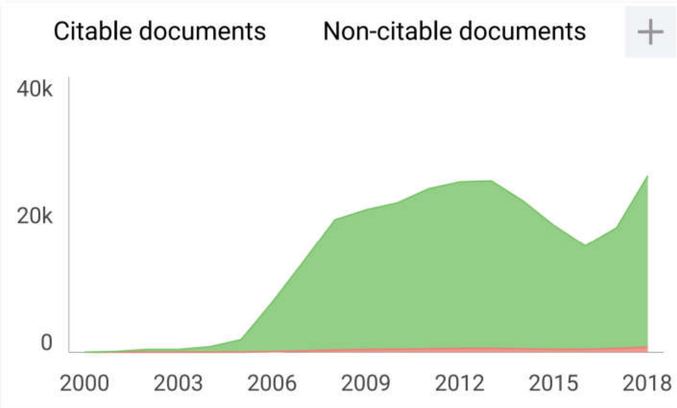
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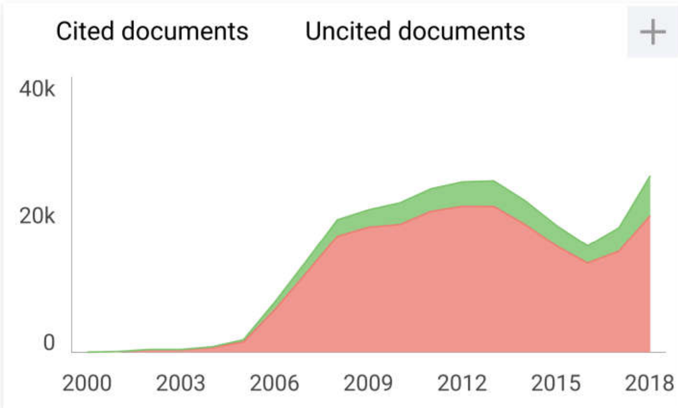
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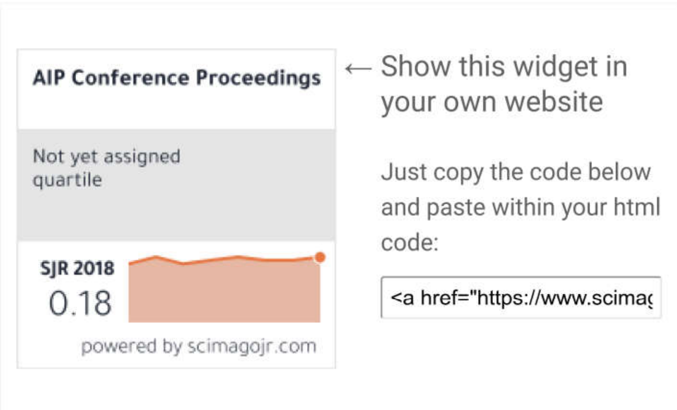
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The Van Hiele Theory and Realistic Mathematics Education: As Teachers' Instruction for Teaching Geometry

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Abstract. Geometry is one of the branches of mathematics lessons learned in school. The teaching geometry in this research that is on teaching and learning of the line and angle material at grade VII Junior High School. The result of this research describes how teachers' instruction for teaching geometry using a combination of the van Hieles' theory with realistic mathematics education (RME). This research is a development research using ADDIE development model (Analysis, Design, Development, Implementation, and Evaluation). This research was conducted at one public school in North Lombok Regency of Indonesia with the subject of research as many as 22 students. There are three aspects that we want to know related to students' responses with using the Van Hieles' theory combination with RME, namely the understanding of the material being studied, students' mathematical connection ability, and the interest in the method.

INTRODUCTION

Geometry is a partial one in the curriculum of mathematics learning that is important to learn in school [1]. Usiskin [2] states there are several reasons why geometry needs to be learned in school: geometries are studied visually; geometry is related to the physical realm; and geometry is a mathematical system. Although geometry is an integral part of the curriculum, many students fail to develop an in-depth understanding of basic geometry concepts [3]. Based on these problems, it becomes important to be noticed by all parties, especially teachers, to find solutions how teaching and learning mathematics get well, especially geometry, to get optimal learning outcomes.

Sugiman [4] said "the success of mathematics learning processes cannot be separated from using appropriate learning methods". The learning method is a way of providing learning materials for students to achieve teaching objectives that have been set [5],[4]. One of the learning theories that can facilitate the development of students' thinking ability levels in studying geometry is van Hiele's theory. This theory was initiated by Dutch educator pair Pierre van Hiele & Dina van Heile-Geldof in 1957. In addition, this theory can also be used as an instructional teacher [6]. Then one of the approaches to learning mathematics is also well known that is realistic mathematics education (RME). This theory triggered by Hans Freudenthal in 1950 that is 7 years before van Hiele theory emerged. This learning approach uses the context of "real world" as a starting point in conveying mathematical concepts to students. Thus, the goal to combine these two methods of learning in the learning and teaching of mathematics, the students' mathematics learning outcomes, especially geometry, can be better in the future and can improve conceptual understanding and interests of students' in learning mathematics. The description of these two learning models will be explained as follows.

Overview of the Van Hiele Theory

According to Piere van Hiele & Dina van Heile-Geldof [7], students in geometry study will go through five levels of hierarchical thinking ability. Students cannot reach one level of thinking (n level) without passing the

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previous level (n-1 level). The five levels are level 1 (visualization), level 2 (analysis), level 3 (informal deduction), level 4 (deduction) and level 5 (rigor). More will be explained as follows.

- Level 1 or visualization. At this level, students use their thoughts in visual form. Students recognize geometrical shapes based on their "overall" shape and compare the shapes based on a given figure or everyday objects. They use simple language. But it can not identify the properties of geometrical shapes [8].
- Level 2 or level of analysis. At this level is already seen the existence of student analysis to the concept and properties of geometrical shapes. Students can determine the properties of a figure through observation, measurement, drawing, and modeling. However, students have not been able to fully explain the relationship between the properties [6].
- Level 3 or level of informal deduction. Students at this level of thinking can already see the relation of attributes to a figure. Students can give informal arguments. For example, on a parallelogram to the parallel opposite side resulted in the same opposite angles, as well as the relationship between multiple the shapes, such as squares are rectangles because they have all rectangular properties [6].
- Level 4 or Level of Deduction. At this level, students can provide evidence of deductive geometry. They understand the role of definitions, theorems, axioms, and evidence. They have been able to distinguish between necessary and sufficient conditions [8].
- Level 5 or Level Rigor. At this level students formally reason in mathematical systems and can analyze the consequences of axiom manipulations and definitions. The interconnections between undefined forms, axioms, definitions, theorems and formal proofs can be understood [9]. At this level, students require complex and complex thinking level, therefore this level is rarely achieved by high school students.

According to some experts, in addition to these five levels of thinking, there is a level of geometric thinking of students who stated not yet to the category level 1 base on van Hiele's theory. The level is called Level 0 or the Pre-Visualization level [10]. In relation to these five levels of geometric thinking, there are also five phases of sequential geometry study according to van Hiele's theory, namely phase of inquiry/information, directed orientation, explication, free orientation, and phase of integration [3],[6],[7]. The five phases of learning will be explained as follows.

- Phase 1: Inquiry / Information. Teachers and students do questioning, then students observe the examples and not examples of a concept through existing information [8]. The purpose of this activity is: (1) the teacher learns the initial knowledge that the students have on the topic discussed. (2) the teacher learns the instructions that appear in order to determine the next lesson to be taken [6].
- Phase 2: Directed Orientation. Learning is designed to explore problems or objects (by rotating, folding, measuring, drawing) to obtain the implicit nature of an example/concept with teacher guidance [7].
- Phase 3: Explication. Students make a temporary conclusion with their own language and convey the results of the discussion then do question and answer between students and students as well as between teachers and students [6].
- Phase 4: Free orientation. At this phase, students learn by using more complex tasks independently to find relationships (for example, knowing the nature of one type of form, investigating these qualities for a new form, such as a kite) [7].
- Phase 5: Integration. At this phase, students summarize all the lessons learned and then reflect and gain new knowledge [7].

Overview of the Realistic Mathematics Education (RME)

Realistic mathematics education is a learning approach that uses the "real world" as a starting point, then the students build a model of the situation and then develop a model for the formal mathematical model to complete so as to gain formal knowledge [11]. The real world according to Blum & Niss [12] is everything beyond mathematics, like other subjects other than mathematics, or everyday life and the environment around us. Meanwhile, according to Panhuizen [13], the word "realistic" is often misunderstood as "real world". The use of the word "realistic" actually comes from the Dutch "zich realiseren" which means "to imagine". The word "realistic" does not simply indicate a connection to the real world but rather refers to the focus of realistic mathematics education (RME) in placing emphasis on the use of a situation imaginable by students.

In RME, mathematics is seen as a human activity, so learning activities use real context and appreciate students' ideas. Based on that view, Gravemeijer [11] developed four basic principles of RME, namely: (1) Guided-reinvention; (2) progressive mathematizing process; (3) the use of didactic phenomenology as Freudenthal has argued; and (4) the development of the model by the students themselves (self-developed model).

As an operationalization of the core principles of RME above, Traffers [14] formulated five RME characteristics: (1) the use of context "real world" for students; (2) the use of models to help students achieve higher understanding; (3) the use of student constructions; (4) natural interactivity in the learning process between students with teachers and students with students; and (5) association with various mathematical units/topics.

METHOD

This study aimed to design and develop interventions (such as learning and teaching strategies, teaching materials, products, and learning systems) as a solution to problems in mathematics learning, especially on line and angle materials. This research is a development research using the ADDIE development model (Analysis, Design, Development, Implementation, and Evaluation) [15]. From this model, the research phase is designed as follows: (1) analysis/introduction (analysis of student needs and designing syntax of learning model), (2) make a prototype and develop instructional through Focus Group Discussion (FGD), and (3) assessment (conducting field trials and data collecting student response). FGD involve expert lecturers and education practitioners (mathematics teachers) to get syntax and learning prototypes (learning tools such as tools, attributes, and media) that are valid to use. A valid product development is implemented in a field trial. The subjects in this study are students Grade VII numbered 22 students with a range of age 12 to 13 years at one public school in North Lombok Regency of Indonesia. Data collection techniques in this study are using tests and questionnaires. Tests are used to measure aspects of the understanding of the material being studied and students' mathematical connection ability. Then the questionnaire is used to measure the aspects of the interest in the method. Data analysis technique in this research that is using scale conversion 5, that are excellent, good, enough, poor, and fair.

RESULTS AND DISCUSSION

The syntax of learning resulting from this study is a new instructional teacher that can be used in teaching and learning geometry resulting from the combination of two learning models namely the van Hiele Theory and RME. Its syntax consists of five phases that can be seen in Figure 1 below.

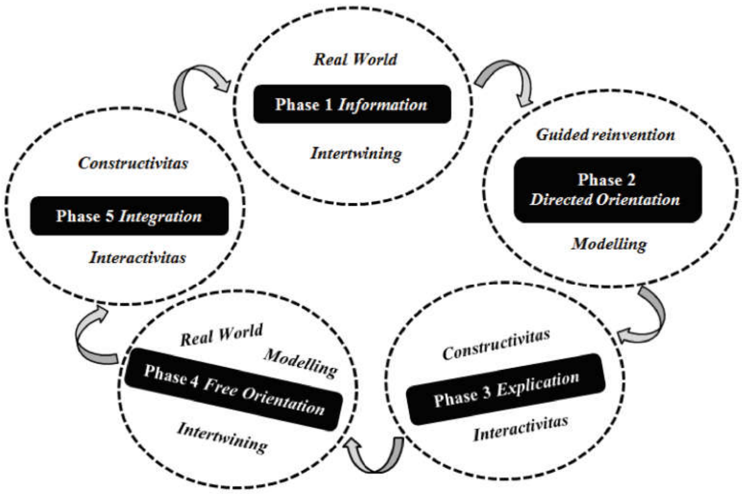


FIGURE 1. Syntax model combination of the van Hiele Theory and RME

The explanations for each of the learning phases in the syntax in Figure 1 are as follows.

Phase 1: Information. Teachers and students take responsibility, then students save the sample and not from the Concepts that exist. The RME characteristics that are used are real-world and intertwining, which are problems that can be imagined and recorded by students or issues related to everyday life. Through the given problem, learning is designed to have a connection, be it connections between mathematics and mathematics, mathematics with other lessons, or mathematics with real life.

Phase 2: Directed orientation. Learning is designed to explore problems or objects (by rotating, folding, measuring, drawing) to obtain the properties of an example/concept with teacher guidance. The characteristics of RME used here are guided reinvention and developing a model that teachers guide students to obtain examples and the nature of a concept of a given problem and provide an opportunity for students to do mathematization to obtain the formal mathematics of the problem.

Phase 3: Explication. Students make a temporary conclusion with their own language and convey the results of the discussion then do question and answer between students and students as well as between teachers and students. The characteristics of RME used are the utilization of construction result and student interactivity.

Phase 4: Free orientation. Students practice independently exploring more complicated tasks with open issues to derive examples and characteristics of a concept. The characteristics of RME used here are using real-world problems, developing models and intertwining.

Phase 5: Integration. Teachers and students make conclusions about the topics they have learned. The characteristics of PMR used are the utilization of construction result and student interactivity.

Teacher Instruction Based on the Combination Model of Syntax

The learning activities used a combination model of van Hiele Theory and RME on the Line and Angle materials at Grade VII in one of the public junior high schools in North Lombok Regency, Indonesia, are described as follows.

The first activity (Phase of Information), to start learning, the teacher asks the students to mention examples of angles in everyday life that students know. This activity aims to know the students' early ability to the concept of angle. In the end, students understand the concept and not the concept of the angle, then know that in learning mathematics there is a relationship between mathematics with real life.

Then in the second phase (Directed Orientation), students are directed to explore the building of "cube" which is used as a attribute in learning. The use of an combination of two-dimensional (2D) and three-dimensional (3D) shapes makes it easy for teachers to introduce the concept and ease for students to understand the concepts provided. In addition, the use of 2D and 3D also shows that the concept in mathematics has a connection between ideas in mathematics. Modeling in this activity is when students understand the concept of the angle through real context (cube) is given. This is in line with the opinion that "mathematical connection supports students to comprehend a concept substantially and assists them to improve their understanding and it's helps students provide a mathematical model that illustrates the relationship among concepts, data, and situation" [16],[17]. Here is an overview of learning activities:

Teacher: Look at the cube (Figure 2)! Which includes two parallel lines? (Use one of the flat you know!)

Student: Line segment of AB is parallel to the line segment of CD.

Teacher: Which two segments intersect?

Student: Line segment of AB intersected by line segment of BC.

Teacher: What is formed if two segments intersect? (Can you find it in an example of real life?)

Student: There are corners and points of intersection.

Teacher: What happens at a corner?

Student: Two sides join.

Activities in Phase 3 (Explication) is students make a temporary conclusion with their own language and convey the results of the discussion then do question and answer between students and students as well as between teachers and students.

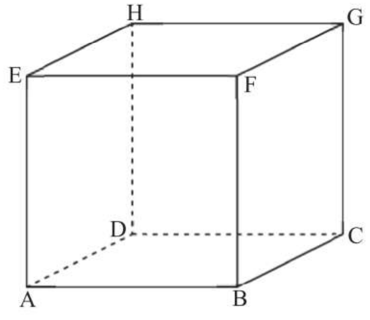


FIGURE 2. Learning attribute is "Cube ABCD.EFGH"

Activities in phase 4 (Free Orientation) is students are asked to explore sketches of the primitive mosque skeleton of Bayan Village, North Lombok Regency, Indonesia by naming and measuring the angle. After the student explores, the teacher asks the students to count the total size of angles on each shape that exist through the sketch of the mosque.

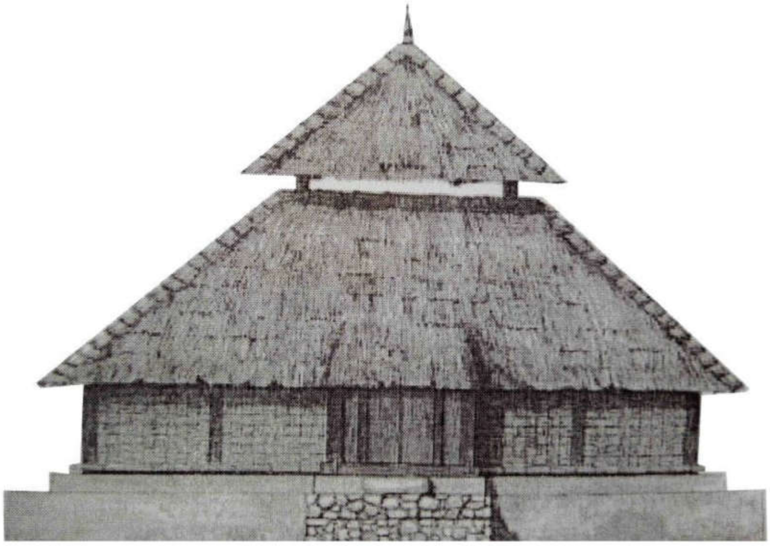


FIGURE 3. The primitive mosque at Bayan Village. It is a historic mosque (first mosque) when the entry of Islamic civilization in Bayan Village North Lombok.

Overview of the results of student exploration in Figure 4 and Figure 5.

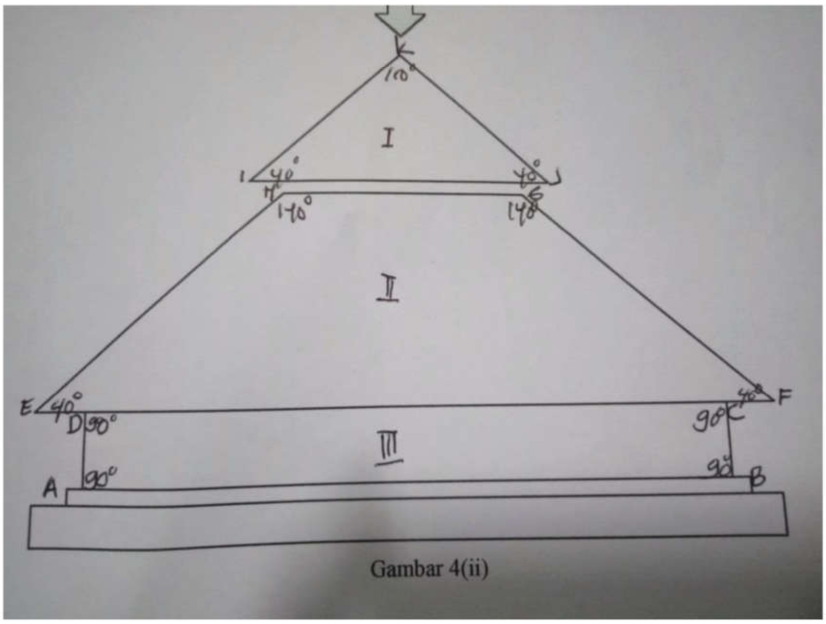
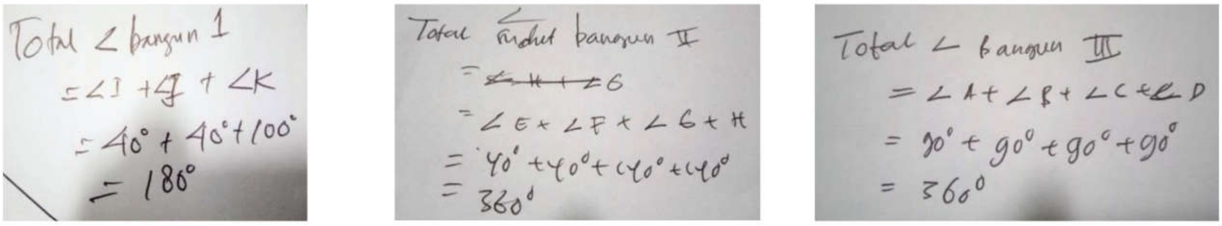


FIGURE 4. Student exploration results by naming and measuring the angle

From Figure 4, students explore the sketches of the primitive mosque by naming each corner they know using capital letters. Then, the students measure every angle they have named. Modeling in this activity is when students explore the concept of the angle through the real context (sketches of the primitive mosque) given. The use of the "real world" context here shows that the mathematical concept has a connection between real life. This activity is in line with the statement that “mathematical connections must also be related to real life” [1].

After the student explores, from Figure 4, the teacher too asked the students to count the total size of angles on each shape that exist through the sketch of the primitive mosque. This is done so that the students indirectly know that the total size of the angle in the quadrilateral = 360º and the triangle = 180º. In addition, this becomes important to do because basically, the concept of inter-mathematics has a connection [1], [18]. The results of student calculations can be seen in Figure 5.



(a) (b) (c)

FIGURE 5. Student exploration results from Figure 4: (a) total size of angles on shape 1, (b) total size of angles on shape 2, and (c) total size of angles on shape 3

Analysis of Students Response with the Combination Model of Syntax

There are three aspects that we want to know related to students' responses with using the van Hieles' theory combination with RME, namely the understanding of the material being studied, students' mathematical connection ability, and the interest in the method. Recapitulation of students' responses presented in Table 1.

TABLE 1. Recapitulation of students' responses

No	Aspect	Responses				
1.	Understanding of the material being studied	Excellent 4(18.2%)	Good 5(22.7%)	Enough 6(27.3%)	Fair 4(18.2%)	Poor 3(13.6%)
2.	Students' mathematical connection ability	Excellent 3(13.6%)	Good 5(22.7%)	Enough 7(31.8%)	Fair 2(9.1%)	Poor 5(22.7%)
3.	Interest in the method	Very interested 5(22.7%)	Interested 7(31.8%)	Enough 7(31.8%)	Fairly interested 2(9.1%)	Not interested 1(4.5%)

From Table 1, there are 18.2% of students having the excellent understanding of the material, 22.7% of students are in a good category, 27.3% are in enough category, 18.2% of students are in a fair category, and 13.6% are in a poor category. Based on these results, it can be concluded that students' understanding of the material that has been studied using the syntax of combination can be quite good. It can be because most of the students are in enough category (27.3%). Then if seen from the comparison between the percentage of excellent and good category (40.9%) with the percentage of fair and poor category (31.8%), so it shows that the percentage of excellent and good category more than the percentage of a fair and poor category. Furthermore, for students' mathematical connection ability aspects: there are 13.6% students in the excellent category, 22.7% are in a good category, 9.0% are in a fair category, and 22.7% are in a poor category. Based on the result of mathematical connection ability test, the percentage of students with enough category still dominates from another category, that is 31.8%. Then, comparison of percentage between excellent and good category (31.3%) more than the percentage of fair and poor category (31.8%), so from this result, the use of syntax combination between van Hiele theory and RME can be said to be effective for use in teaching and learning mathematics, especially geometry material.

Then, for the interest in the method aspect: there are 22.7% of students stating very interested in the method, 31.8% of students stating interested to use the method, 31.8% are in enough interested, 9.1% of students stating less interesting, and 4.5% of the students stating not interested in the method. This means that most students are interested in the method of learning that has been used. Although some students still not interested in the methods that have been used. However, as a whole, it can be inferred that the use of this method in mathematics instruction gives a positive impact on students' interest. From this result, this method can be recommended as one of the learning methods to increase students' interest in learning mathematics, especially geometry.

CONCLUSION

The combination model of van Hiele theory with realistic mathematics education (RME) approach is designed using Van Hieles Theory syntax which contained the characteristics and principles of the RME approach. In general, more than 50% of students responded positively to the application of this combination model in mathematics learning, when viewed from three aspects, namely the understanding of the material being studied, students' mathematical connection ability, and the interest in the method. Furthermore, for instructional mathematics, this combination model still needs to be developed further. It aims to improve students' positive responses in the following study with this combination model.

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