International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

Development of Geometry Learning Devices According to Van Hiele Theory and Wingeom Assisted Guided - Discovery Learning Model

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Abstract: ***This research was conducted at Satap Molingongot State Junior High School. This study aims to produce development products for geometry learning tools in the form of Lesson Plans, Worksheets, and Learning Outcomes Test Instrument that meet valid, practical and effective criteria using the modified 4 - D Thiagarajan development model. The results of the study show that learning tools meet valid criteria, which is seen from the results of validation from experts with an average value given of 4.16 for lesson plans, 4.07 for worksheets and 3.89 for THB. The results of the practicality test show that the learning device meets the practical criteria, which can be seen from the results of the observation sheet the teacher's ability to manage learning is in the very good category and the results of the student response questionnaire analysis are on average 4.72 which concludes that the student response is positive. While the results of testing the effectiveness of learning devices meet the effective criteria, namely the percentage of classical completeness of student learning outcomes tests is 80%.***

Keywords: Development of learning tools, Van Hiele, Guided - Discovery Learning, Wingeom, Geometry

1. Preliminary

Carrying out the process of learning mathematics in better and quality schools is a necessity that cannot be negotiated. In the process of learning mathematics at school directs students to achieve predetermined competency standards. Mathematics learning activities are not oriented towards mastery of mathematical material alone, but mathematics material is positioned as a tool and means for students to achieve competency. Therefore, the scope of mathematics subjects studied at school is adjusted to the competencies students must achieve. PPPPTK Mathematics (2011), referring to competency standards and basic competencies that must be achieved by students, then one of the areas that becomes the scope of mathematics material is geometry. Geometry as a field of study in school mathematics material obtains a large portion for students to learn. Geometry taught in schools is useful for increasing students to think logically and make generalizations correctly.

NCTM (Tussolihah, 2015) states that in general the geometric abilities that students must have are: (1) Being able to analyze the character and properties of geometric shapes, both 2D and 3D, and being able to build mathematical arguments regarding the relationship of geometry with others; (2) Be able to determine the position of a point more specifically and describe spatial relationships using geometric coordinates and linking them with other systems; (3) Application of transformations and using them symmetrically to analyze mathematical situations and (4) Using visualization, spatial reasoning, and geometric models to solve problems. The reality is that students' mathematical thinking skills and geometric visualization abilities have not developed optimally and are still relatively low (Sutama et al, 2014). Based on the results of interviews with the mathematics teacher in class VIII of SMP Negeri SatapMolingongot, many students experienced difficulties in learning geometry, especially in the material of flat sided shapes so that student learning outcomes were low. Students have difficulty visualizing geometric shapes, distinguishing the properties of geometric shapes, having difficulties in solving problems related to flat - sided geometric shapes, and difficulties in geometric modeling to solve existing problems. This difficulty is experienced in the learning process because learning tools have not been developed to help students learn geometry, teachers only use visual images in books at school and rarely even use learning media. This kind of learning is less effective because students cannot visualize these geometric shapes so they do not understand the concepts.

A systematic learning and media that can help students' visualization is needed. One theory of learning geometry that can be used is Van Hiele's theory. According to Van Hiele's theory, a person will go through five stages of development of thinking in learning geometry. The five stages of development of van Hiele's thinking are Stage 0 (Visualization) at this stage students recognize geometric shapes based solely on visual characteristics and appearance; stage 1 (Analysis) in this stage students can determine the properties of a figure by observing, measuring, experimenting, drawing, and making models; stage 2 (Informal Deduction) then at this stage students can already see the relationship of the properties of a geometric shape and the properties between several geometric shapes; stage 3 (Deduction) at this stage students can compile evidence, not just accept evidence. Students can construct theorems in the axiomatic system; and stage 4 (Rigor) at this stage students reason formally in mathematical systems and can analyze the consequences of manipulating axioms and definitions (Abdussakir, 2009). To increase a stage of thinking to a higher stage of thinking, learning phases are

determined which indicate student learning objectives and the teacher's role in learning, namely: (1) information phase: at this level, teachers and students use questions and answers and activities about objects - Objects studied at the stage of student thinking. The teacher asks questions to students while making observations. The purpose of this activity is for the teacher to study the initial experiences students have about the topic discussed, and the teacher studies the clues that appear in order to determine the next lesson to be taken. (2) orientation phase: Students explore the topic studied through the tools that the teacher has carefully prepared. This activity will gradually reveal to students the structure that gives the characteristics of the components and the relationships between the components of a figure. Tools or materials are designed into short tasks so that they can elicit a specific response. (3) explanation phase: Based on previous experience, students express their emerging views about the observed structure. Besides that, to make students use appropriate and accurate language, the teacher provides as little assistance as possible. This lasts until the system of relationships at the thinking stage is evident, (4) free orientation phase: Students face more complex tasks in the form of tasks that require many steps, tasks that are completed in many ways, and tasks that are open - ended. They gain experience in determining their own way, as well as in completing tasks. Through orientation among students in the field of investigation, many relationships between objects become clear, and (5) integration phase: in this phase students review and summarize what they have learned. Teachers can assist students in making this synthesis by completing a global survey of what has been learned. This is important, but this conclusion does not represent anything new. At the end of this fifth phase students reach a new stage of thinking. Students are ready to repeat the learning phases at the previous stage.

Safrina et al (2014) stated that improving students' geometry problem - solving abilities by using van Hiele's theory - based cooperative learning was better than conventional learning. Husnaeni (Abdusakkir, 2009) states that the application of the van Hiele model is effective for improving the quality of students' thinking. Beni Junedi (2017) stated that learning mathematics using Van Hiele's learning theory on geometry material in general can increase student learning activities. Based on the opinion above, in learning geometry through the Van Hiele learning phase students will be directed and guided in thinking systematically and in an organized way. In order for students' understanding of concepts and visualization in learning geometry to be effective and innovative, appropriate learning media and models are also needed. One of the innovation media for learning geometry is the Wingeom application program. Wingeom is one of the dynamic software (Dynamic Mathematics Software) for the topic of geometry. This program can be used to help learning geometry and solving geometry problems. The Wingeom program is a program that can be obtained and used free of charge (totally freeware) by downloading from the website. As an illustration, one of the views of the application program is shown in Figure 1.1.

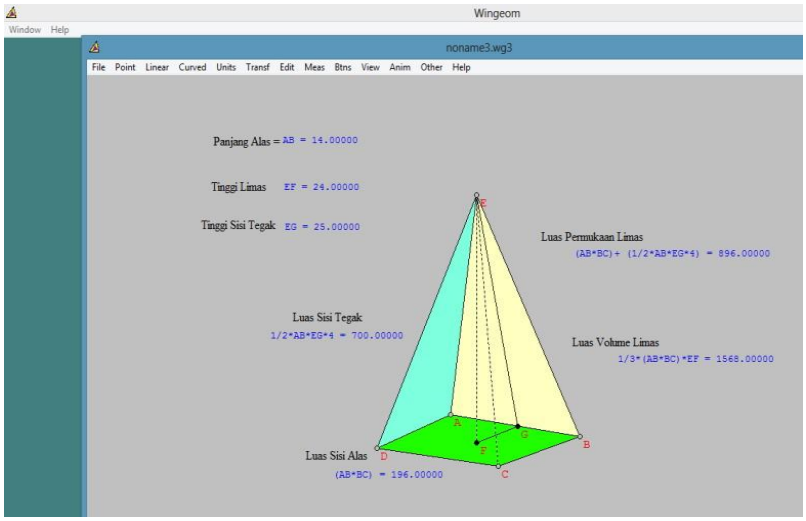

Figure 1.1: Example of a 3 - dimensional Wingeom View

This program loads the 2 - dim Wingeom Programs, for two - dimensional geometries and the 3 - dim Wingeom Programs for three - dimensional geometries, in separate windows. In addition, it also contains programs for hyperbolic geometry and spherical geometry. The Wingeom Program facilities are quite complete, both for the second dimension and for the third dimension. One of the interesting features of this program is the easy animation facility. Harjanto (2011) in his research said that students' responses to learning were very positive, because the Wingeom Program really helped visualize geometric shapes that had been difficult to see on paper and blackboard media, so that with the help of this media students could build existing geometric concepts.

In addition to learning media, appropriate learning models are also needed to support the learning process to make it more practical. The guided discovery model involves a dialogue or interaction between students and teachers where students seek the desired conclusions through a sequence of questions set by the teacher (Markaban, 2008). Akanmu and Fajemidagba (Rustam, 2021) stated that there was a significant difference in the learning outcomes of students who were taught using the Guided - Discovery Learning

strategy compared to those who were not taught using guided - discovery learning. The guided discovery model involves a dialogue or interaction between students and teachers where students seek the desired conclusions through a sequence of questions set by the teacher (Markaban, 2008). Interaction can also be carried out between students both in small groups and large groups (classes) in carrying out activities or discoveries in small groups, students interact with one another. Interaction can occur between the teacher and certain students, with several students, or simultaneously with all students in the class. The goal is to mutually influence each other's thoughts, the teacher provokes students' thinking, namely with focused questions so as to enable students to understand and construct certain concepts, build rules and learn to find something to solve problems. According to Bruner (Winataputra, 2014) the stages of applying discovery learning, namely; Stimulus, Problem statement, Data collection, Data Processing, Verification, Generalization.

2. Research Procedure

Efforts to obtain valid, practical and effective learning tools which include lesson plans, worksheets and THB are carried out using development research procedures according to the 4 - D model (Thiagarajan S, 1974) with stages that include Define, Design, Development. and Desimination. Given the limited time and funds, the researchers adopted this model as modified by Trisna (2005) with the first 3 (three) stages. The development research scheme is shown in Figure 2.1. The data captured at the Development stage are validity data, practicality data and the effectiveness of the Flat Sided Building learning device based on the van - Hielle Theory in the Guided - Discovery Learning model with the help of the Wingeom application media.

3. Results and Discussion

The results obtained at the Defining stage were: (1) the results of the early - end analysis showed a fundamental problem faced by teachers in increasing student activity, namely that there was no learning media that helped visualize students, especially on flat - sided geometric material, students only used books in the form of textbooks government as a source of learning, there is no LKS that helps the learning process and the learning that is carried out is still teacher - centered learning so that students' abilities are not explored by the teacher in the learning process. Students tend to be less interested and not active in learning mathematics because the available learning tools are less attractive and not yet innovative. Efforts that can be made to solve this problem are to develop learning tools that can help students understand the flat sided geometric material according to Van Hiele's theory and the Guided - Discovery Learning model. Furthermore, to help visualize students, namely by utilizing the learning media of the Wingeom program. (2) the results of the student analysis show that students who study the Flat Side Building material use the Indonesian language of instruction with the local dialect. Students generally have a healthy physical condition and are able to write, read and do their daily activities well. They are already able to distinguish between solid and spatial shapes, know about points and lines. The obstacle in the aspect of students' knowledge is that they have not been able to distinguish between cubes and blocks. (3) the results of the concept analysis show that students learn the concept of flat sided shapes based on the 2013 curriculum with the competence achieved to distinguish and determine the surface area and volume of flat sided shapes (cubes, blocks, prisms, and pyramids); and solve problems related to the surface area and volume of flat side shapes (cubes, blocks, prisms and pyramids), as well as their combinations.

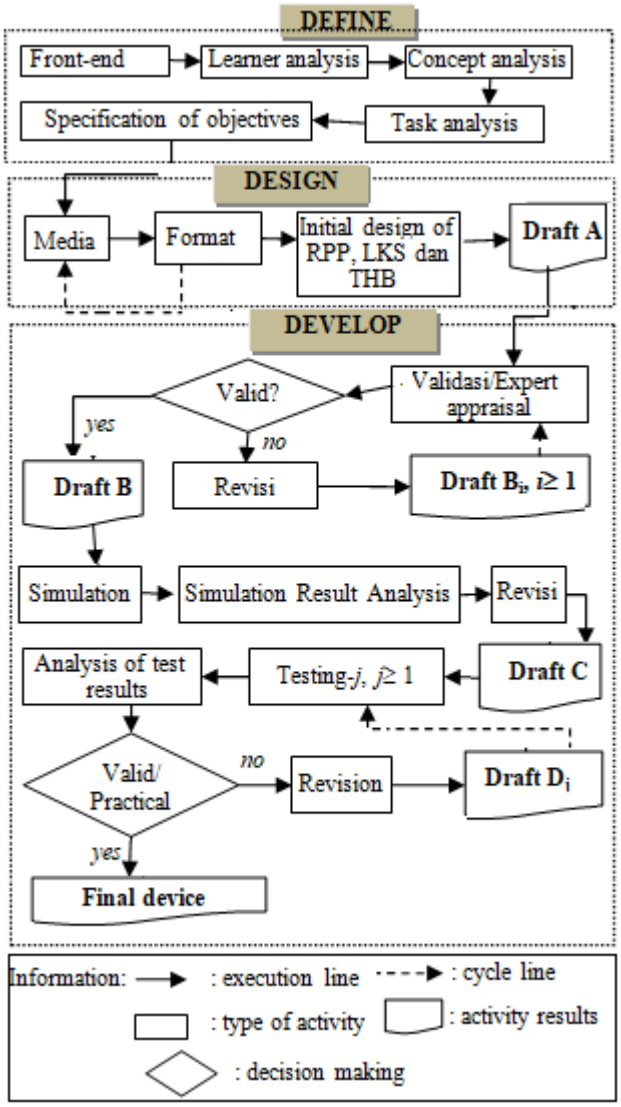

Figure 2.1: Modification of the 4 - D Learning Device Development Model adopted from (Trisna, 2005)

(4) The results of the task analysis are tasks that refer to indicators of achieving competence, namely: (a) Recognizing and understanding the elements of cubes and blocks, (b) Determining the surface area of cubes and blocks, (c) Determining the volume of cubes and blocks, (d) Solve problems related to the surface area and volume of cubes and blocks. (5) the results of the specification of objectives in each meeting are Meeting 1: In the learning process students carry out observations and discussions in groups using LKS and Wingeom displays so that students can determine the surface area of a cube and solve problems related to the surface area of a cube. Meeting 2: In the learning process students make observations and discuss in groups using worksheets and the Wingeom display so that

students can determine the surface area of a block and solve problems related to the surface area of a block. Meeting 3: In the learning process students make observations and discuss in groups using LKS, Wingeom displays and teaching aids so that students can determine the volume of cubes and blocks and solve problems related to the volume of cubes and blocks.

The results at the design stage are: (1) the results of selecting the media to be used in learning the flat sided geometric material, namely the Wingeom computer program which can help students visualize the material of cubes and blocks. At this stage the researcher designed the cubes and blocks on Wingeom in accordance with the learning objectives that must be achieved by students and adapted to the existing material. Apart from Wingeom, media and other learning tools that will be used are visual aids, laptops, LCDs, powerpoints, dyes, rulers, and other writing instruments. The visualization of cubes and blocks in Wingeom is shown in Figure 3.1.

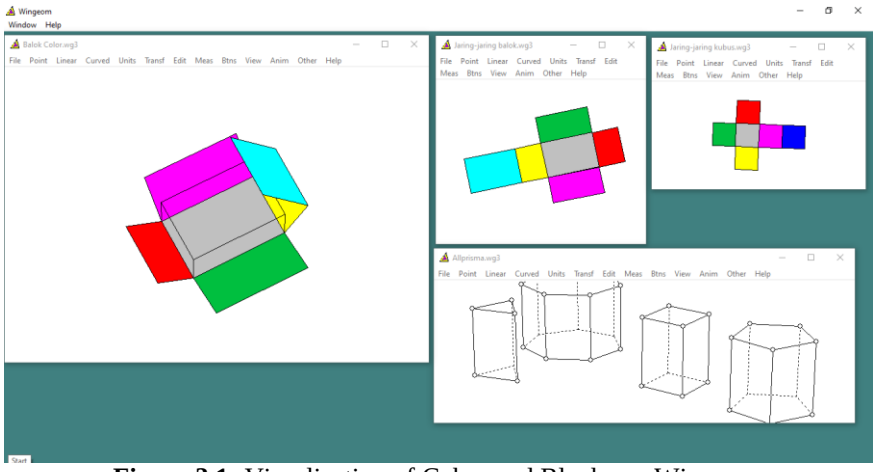

Figure 3.1: Visualization of Cubes and Blocks on Wingeom

(2) the results of selecting the format for the learning tools to be developed are adapted to the understanding of geometry according to Van Hiele's theory and the steps in the Guided - Discovery Learning model, using the revised edition of RPP 1 Curriculum Sheet 2013 format. The learning implementation plan contains basic competencies, indicators, learning objectives, learning media and learning resources, learning models, learning steps, and assessments. Worksheets that are made are designed to be more attractive and make it easier for students in the learning process so that students will be interested and motivated in learning. THB adjusts to competency achievement indicators so that learning objectives are expected to be achieved. (3) the results of the initial design of the learning device are the design of the learning device, namely lesson plans, worksheets for three meetings and THB along with scoring guidelines and answer keys. In addition, the RPP developed was designed based on Van Hiele's understanding of geometry and the Guided - Discovery Learning model assisted by the Wingeom program. The lesson plans compiled in this study are for 3 meetings.

Results of the Development stage: (1) results of the validation of the RPP, LKS and THB carried out by 3 validators as shown in the following data analysis. The results of the RPP validation by 3 validators provide a value with an average value of 4.16. Although there are revisions that still need to be done in order to produce a better device. From the results of the validator's assessment, it can be seen that the components in the RPP get an assessment with Very Good criteria, which means that the RPP has met the valid criteria. The results of LKS validation by 3 validators show that the designed LKS is in the Very Good category with a few revisions. The follow - up is to revise according to the suggestions from the validator so that the prepared worksheets can be used. The results of THB validation were carried out by expert validation with the criteria that were seen were content validity, language and writing indicating that THB had met the valid criteria for content validity, was very understandable for language and question writing and could be used with slight revisions according to the suggestions of the three validators. After being revised, an analysis of the validity of the test items and the reliability of the test was carried out with the results of each THB item having a valid category validity level and a reliability coefficient of r = 0.85 which means that the reliability of the learning outcomes test instrument developed was included in the very high category. The Teacher Ability to Manage Learning Observation Sheet (LOKGMP) was validated by experts before being given to teachers. From the validation carried out by experts on the components in the observation sheet, they meet very valid criteria and are suitable for use. The Student Response Questionnaire (ARS) was validated before being given to the trial subjects. Data validation results of student response questionnaires as a whole obtained an average total validation value of 4.41 and are in the very good category and it can be concluded that the Student Response Questionnaire is very valid to use. Up to this point the development results obtained show that the RPP, LKS and THB as well as the LOKGMP and ARS instruments have met the valid requirements. Furthermore, field trials were carried out and obtained data on the teacher's ability to manage learning. The results of the analysis showed that at the first meeting, the teacher's ability to manage learning reached the good category, at the second meeting it reached the very good category and the third meeting reached the very good category. Based on the results of the analysis, it can be concluded that the teacher

has carried out the planned learning well, which means that the lesson plans for lesson plans, worksheets and THB meet the practical category. Data on student learning outcomes captured using THB showed that 80% of students achieved complete learning outcomes. Student response questionnaire data shows that every aspect of the observation was responded positively by all students. The results of this analysis indicate that the RPP, LKS and THB learning tools meet the effective category. Overall, it has been found that the learning materials for Flat Sided Building Materials according to Van Hiele's theory and the Guided - Discovery Learning model assisted by Wingeom meet the valid, practical and effective criteria. The results obtained are in line with research conducted by Deshinta P. A. D. A. students of the Masters in Mathematics Education Study Program, FKIP Sebelas Maret University Surakarta, 2018 with the research title: "Development of Geometry Learning Modules Based on Van Hiele's Theory on the Subject of Quadrilaterals Class VII SMPN 1 Selogiri". The results of this research and development are in the form of modules with valid, practical, and effective criteria. The results of the validity test show that the module meets the valid criteria, i. e. all validators state that the module is based on a strong theoretical foundation and the module components are consistently related. The practicality test results show that the module meets the practicality criteria, namely experts say the module can be used in learning and the percentage of implementation of learning using the module reaches more than 80%. The results of the effectiveness test show that the module can meet the effectiveness criteria, namely (1) the percentage of students' positive responses is more than 50%, namely 87% in the trial class and 86.6% in the experimental class, (2) more than 30% of students experience an increase in the level students' geometric thinking, namely 48% of students in the trial class, and (3) statistical tests showed that the use of developed learning modules was more effective in increasing the level of students' geometric thinking compared to the use of textbooks. Research conducted by I Ketut Sutama, I Gusti Putu Suharta and Gede Suweken students of Ganesha University of Education, 2014 with the research title: "Development of High School Geometry Learning Devices Based on Van Hiele Theory and the Guided - Discovery Learning model assisted by Wingeom in Efforts to Increase Student Activities and Learning Outcomes. With the results of learning device research that is valid, practical, and effective. The learning characteristics obtained are (1) learning begins with the process of information through visualization on the media; (2) students explore through a guided orientation process; (3) through the process of explicitation, students express ideas resulting from exploration; (4) through the free orientation process, students provide examples to deepen their understanding; and (5) through the integration process, students summarize all their learning experiences. The characteristics of the student book are (1) it contains steps of Van Hiele's theory in the form of learning activities; (2) student learning activities are supported by wingeom. The characteristics of the teacher's manual are (1) it contains implementation of learning based on Van Hiele's theory; (2) implementation of learning related to wingeom. The characteristics of learning media are (1) consistent with Van Hiele's theory; (2) according to students' abilities; and (3) can be used as material for exploration. Research conducted by Rika Afrilia, a student at Ar - raniry State Islamic University Banda Aceh, 2018 with the research title: "Use of Wingeom Software on Geometry Learning Outcomes of Students of SMPN 1 Sawang". The results showed that the learning outcomes of students who were taught using the wingeom software media were higher than the learning outcomes of students who were taught with visual aids on pyramid material in class VIII SMPN 1 Sawang. Research conducted by Beni Junedi, Lecturer in the Mathematics Education Study Program at STKIP Insan Madani Airmolek, 2017 with the research title: "Application of Van Hiele's Learning Theory in Geometry Material in Class VIII". The results of the study concluded that learning mathematics using Van Hiele's learning theory on geometry material in general can increase student learning activities.

4. Conclusions and Suggestions

Based on the results of research and discussion obtained: The results of this research and development are in the form of learning tools with valid, practical, and effective criteria. This learning tool was developed based on the 4D development procedure which is limited to 3D which consists of the define, design and develop stages, the fourth stage which was not carried out was the disseminate stage due to time and cost constraints. The three stages carried out are definition which consists of initial - end analysis, student analysis, concept analysis, concept analysis, task analysis then specification of learning objectives. The design stage consists of media selection, format selection and design. In the process of designing learning tools, it consists of planning lesson plans, LKS designs and THB designs as well as media designs in the Wingeom program to help the learning process. The design of these three devices is guided by the 2013 curriculum used in schools that are pilot classes. The development stage consists of expert validation, readability testing, device testing, analysis of trial results. During the testing phase of the device, observations were made through observation sheets on the teacher's ability to manage learning. At the end of the trial phase, a learning achievement test was carried out, and the student response questionnaire was filled out. The results of testing the validity of the developed learning tools show that the learning devices meet valid criteria, which is seen from the results of validation from experts with an average value given of 4.16 for lesson plans, 4.07 for worksheets and 3.89 for THB. The results of the practicality test show that the learning device meets the practical criteria, which can be seen from the results of the observation sheet the teacher's ability to manage learning is in the very good category and the results of the student response questionnaire analysis are on average 4.72 which concludes that the student response is positive. While the results of testing the effectiveness of learning devices meet the effective criteria, namely the percentage of classical completeness of student learning outcomes tests is 80%. The results of this study are an overview of the sample class which only consists of one class. Therefore the developed learning tools need to be tested again in parallel classes so that better learning tools will be obtained. This research also only reaches the development stage or produces a product that is valid, practical, effective. It would be nice to proceed to the further

research stage, namely the product deployment stage to find out how effective the learning tools are.

5. Acknowledgement

The author as a student at the Masters Program in Mathematics Education PPs State University of Manado expresses his highest gratitude to the Manado State University in this case the Postgraduate Program which has provided the opportunity for researchers to study as well as explore the theory and practice of developing mathematics learning tools so that the authors gain the ability more that supports the author's task as a Mathematics teacher.

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