DESIGN DIDACTIC TRIANGULAR PROPERTIES BASED ON THE LEVEL GEOMETRIC THINKING VAN HIELE OF GRADE VII STUDENTS

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\textbf{Abstract}

This research is qualitative research using the didactical design research (DDR) method which was carried out in three stages, namely: (a) analysis of the didactical situation before learning in the form of a Didactic Design Hypothesis including ADP, (b) metapedidactic analysis, and (c) retrospective analysis. Data collection through tests, documentation and questionnaires. The research subjects were students of MTs Negeri 1 Majalengka. Data analysis techniques using descriptive statistics and gain test. The results of this study indicate that from the results of the analysis of students' learning barriers in the material properties of triangles, anticipation is made of the occurrence of learning barriers related to mathematical understanding abilities. Based on the validation carried out by five validators, a cumulative result of 85.4\% is included in the very valid category. The design of teaching materials based on a mathematical understanding of the material properties of triangles can be used in learning. And from the results of the pretest and posttest on the material properties of triangles after and before the implementation of teaching materials there is an increase in the mathematical understanding of 57\% included in the moderate improvement category. Based on the results of the study, it can be concluded that the didactic design with the mathematical understanding and Van Hiele's level of geometric thinking can minimize learning obstacles found, although they are not yet complete and can be used as teaching material recommendations on the material properties of triangles.

\textbf{Keywords}: Didactical design, ability to understand mathematics, learning obstacle, level of thinking in Van Hiele Geometry.

\textbf{Abstrak}

Penelitian ini adalah penelitian kualitatif dengan metode didactical design research (DDR) yang dilaksanakan dengan tiga tahapan yaitu: (a) analisis situasi didaktis sebelum pembelajaran yang wujudnya berupa Disain Didaktis Hipotesis termasuk ADP, (b) analisis metapedadidaktik, dan (c) analisis retrospektif. Pengumpulan data melalui tes, dokumen, dan angket. Subjek penelitian yaitu siswa MTs Negeri 1 Majalengka. Teknik analisis data menggunakan statistik deskriptif dan uji gain. Hasil penelitian ini menunjukkan bahwa dari hasil analisis hambatan belajar siswa dalam materi sifat-sifat segitiga kemudian dibuat antisipasi terjadinya hambatan belajar terkait kemampuan pemahaman matematis. Berdasarkan validasi yang dilakukan oleh lima validator diperoleh hasil komulatif sebesar 85,4\% termasuk dalam kategori sangat valid. Desain bahan ajar berbasis kemampuan pemahaman matematis pada materi sifat-sifat segitiga dapat digunakan dalam pembelajaran. Dan dari hasil melakukan pretest dan posttest pada materi sifat-sifat segitiga sesudah adanya implementasi bahan ajar terdapat peningkatan pemahaman matematis sebesar 57\% termasuk dalam kategori peningkatan sedang. Berdasarkan hasil penelitian dapat disimpulkan bahwa desain didaktis dengan pemahaman matematis dan level bepikir geometri Van Hiele dapat meminimalisir learning obstacle yang ditemukan, meskipun belum secara utuh dan dapat dijadikan sebagai bahan rekomendasi bahan ajar pada materi sifat-sifat segitiga.

\textbf{Kata kunci}: Desain didaktis, Kemampuan pemahaman matematis, Learning obstacle, Level berpikir Geometri Van Hiele.
INTRODUCTION

Geometry is a branch of mathematics that is studied starting from elementary school. Based on Wardhani (2015) one way to develop the ability to think logically by often solving many problems correctly and thoroughly, especially math problems. Based on Mustaqim, Adiwijaya, & Indrajaya (2013) one of the benefits of studying the concept of geometry is its relation to various disciplines such as art, architecture, robotics, astronomy, sports, and so on.

According to Van de Walle in Nopriana (2014) studying geometry through five stages, namely (a) the introduction stage (visualization); At this stage, children begin to learn about geometric shapes as a whole, but cannot yet know the properties of the geometric shapes they see; (b) analysis stage: At this stage, the child has begun to recognize the properties of the geometric objects he observes. He is already able to mention the order contained in geometric objects; (c) sequencing stage (informal deduction); At this stage the child's understanding is more enhanced than before, when only knowing geometric shapes and their properties. At this stage, children can find out the relationship between building geometry and other geometries. Children at this stage already understand the order of geometric shapes; (d) cutting stage: At this stage the child already understands deduction, namely deductively concluding by concluding certain things, and (e) level of accuracy: The final stage of children's cognitive development in understanding geometry is the precision stage. In realizing these learning objectives, several studies were conducted to find out students in learning the concept of geometric properties of triangles.

Research result Maulina et al. (2022) said that students' difficulties in understanding geometrical properties were influenced by three factors, namely: (1) starting from a lack of student interest in learning, especially related to the material properties of rectangles and students' lack of mastery of the material prerequisites, (2) based on the presentation of learning by the teacher, (3) related to the limitations of students' understanding of the material lies in the lack of students' mastery of the concept of flat shapes material with rectangular properties. Based on Fitriani & Rohaeti (2020) The research states that students experience misconceptions in learning geometry. The misconceptions that arise include: lack of familiarity with the elements in geometric shapes; delivery of material that is systematically unstructured; no connection between plane shapes and geometric shapes.

Based on the factors that cause students' difficulties in learning the properties of plane geometry that have been explained by previous researchers, it can be concluded that in addition to internal factors, external factors also influence student achievement in understanding geometric concepts.

The above description concerns student learning barriers, so this research is how to make a didactic design of the geometric concept of triangular properties using Van-Hiele's understanding of geometric thinking. With the aim of minimizing all kinds of concept misunderstandings that result in student learning barriers on the geometric concept of triangular properties.
RESEARCH METHODS

This type of research is qualitative research. According to Murdiyanto (2020) observes group of pictures, analyzing a collection of texts, analyzing words, reporting in detail the results of the respondents is a qualitative research approach. Based on Nugrahani (2014) said that the purpose of this qualitative research is to analyze, understand and observe by leading to a detailed picture of conditions in a natural context. This research method uses the Didactical Design Research (DDR) method.

Based on Suryadi (2013) compiling a didactic design through three stages: the first stage is a hypothetical didactic design which includes ADP, the second stage is a metapedidactic analysis, and the third stage is a retrospective analysis.

Stage 1: Didactical Situation Analysis Before Learning

a. Determine the mathematical material that will be research material.

b. Look for data or literature on the material that has been determined.

c. Study and analyze the material that has been determined.

Stage 2: Metapedadidactic Analysis

a. Implement the didactic design that has been prepared.

b. Analyze situations, and student responses, and anticipate student responses when the didactic design is implemented.

c. Comparing learning outcomes with DDR and conventional learning.

d. Analyze the effectiveness of the didactic design.

e. Compile research reports.

The subject of this research was conducted at MTs Negeri 1 Majalengka which involved two classes, namely class VII and VIII. This research consists of two stages, namely the subject of identifying learning barriers and the subject of applying didactic design. Barriers to learning subjects implemented in class VIII because previously students had received material about the properties of triangles in class VII. The subject of implementing teaching materials based

g. Develop a didactic design, namely with students' difficulties (learning obstacles) regarding the concept of the properties of a triangle.

h. Make predictions of student responses that may arise when the didactic design is implemented and prepare anticipation of student responses that may arise.
on the ability to understand mathematics and the level of thinking of Van Hiele geometry is carried out in class VII because students have not yet received material about the properties of triangles.

RESULTS AND DISCUSSION

The results of this study regarding the didactic design of triangular properties to improve mathematical understanding and the level of van Hiele geometric thinking in junior high school students conducted at MTs Negeri 1 Majalengka carried out a literature study at MTs Negeri 1 Majalengka. This research is in the form of research results and discussion of learning barriers in the properties of triangles, teacher intervention when implementing teaching material designs, and increasing mathematical understanding and the level of thinking of Van Hiele geometry after the implementation of teaching material designs is carried out. The notion of learning obstacle stems from the opinion of Bachelard and Piaget in Brousseau (2006) who said that student errors are not solely caused by ignorance and uncertainty of students in learning a knowledge, then researcher conduct trials first in class VIII who have received material about the properties of triangles in class VII, to find out student learning barriers in this material as a reference for making teaching materials.

The following are the first learning obstacle by students when working on material properties of triangles.

\[
\begin{align*}
\text{a. } & \beta + \gamma = 180^\circ \\
\text{b. } & \theta + \alpha = 180^\circ \\
\text{c. } & \theta + 60^\circ = 120^\circ
\end{align*}
\]

Figure 1. The learning obstacle by student

In Figure 1 the learning obstacle by student lies in applying the triangle angle formula where the angle of $180^\circ$ is not included in the addition operation.

The number one ability indicator is applying formulas in simple calculations. Meanwhile, the material indicator in question number one is to apply the properties of a triangle in terms of its angles. The process of working on these questions based on understanding indicators and material indicators is presented in Table 1.
Table 1. Percentage of ability to understand mathematical problems

<table>
<thead>
<tr>
<th>Ability</th>
<th>Question Indicator</th>
<th>Percentage of Students Who Answered Correctly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applying formulas in simple calculations, and properties of triangles seen from their angles</td>
<td>Apply the properties of triangles in terms of angles</td>
<td>92.5%</td>
</tr>
</tbody>
</table>

Based on the results of the learning obstacle carried out during the trial, it can be seen in Table 2. Then, the didactic and pedagogical anticipations of these questions are presented in Table 3.

Table 2. Distribution of students' ability to work on problems

<table>
<thead>
<tr>
<th>Percentage Learning Obstacle</th>
<th>Students who Answer Wrong</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students cannot apply the formula for the sum of the angles of a triangle to the problem.</td>
<td>7.5%</td>
</tr>
</tbody>
</table>

Table 3. Table of Didactic and Pedagogical Anticipation of Didactic Situations

<table>
<thead>
<tr>
<th>Learning Obstacle</th>
<th>Educational Anticipation</th>
<th>Pedagogical Anticipation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students cannot apply the formula for the sum of the angles of a triangle to the problem.</td>
<td>Students are directed to recall the concept of the properties of a triangle from its angles.</td>
<td>Students are given examples of objects in everyday life related to the angles of triangles.</td>
</tr>
</tbody>
</table>

The created didactic situation is expected to reduce student learning barriers. The following Table 4 predicts student responses after a didactic situation is created.

Table 4. Table of Prediction of Student Responses to Didactic Situations

<table>
<thead>
<tr>
<th>Predicted Response</th>
<th>High Student Ability</th>
<th>Moderate Student Ability</th>
<th>Low Student Ability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students can answer questions correctly.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Students can answer questions according to concepts or formulas, but there are some errors in addition and subtraction operations.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Students answer questions incompletely.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Based on the results of the research stages above, it was obtained several learning obstacles experienced by students as follows. Ignorance in applying the formula for the inside and outside angles of a triangle. Students' difficulties resulted in errors in finding one of the corners of the triangle because students did not master the properties of a triangle seen from the angle. The solution to overcome this problem is that students are directed to the material properties of triangles in terms of angles and pedagogically students are given examples of objects in everyday life related to triangular angles.

According to Annizar & Suryadi (2016) didactic design is used in the learning process to support student learning activities which are arranged based on learning objectives. According to Setiadi, Suryadi, & Mulyana (2017) learning activities in didactic design must consider the learning barriers experienced by students, this aims to
obtain a learning trajectory. The design was made to support teachers in designing appropriate learning activities for their students in Gogoulou & Grigoriadou (2021); Hernández-Leo et al. (2019); and Konnerup et al. (2018). This is done so that the learning process can improve the quality of learning outcomes in the teaching and learning process Karga & Satratzemi (2019). Maka after obtaining learning barriers for students, the researchers then compiled an initial draft of the HLT concept about the properties of triangles. According to Astuti & Wijaya (2021) hypothetical learning trajectory contains three main learning trajectory components, namely: 1) learning objectives to be achieved, 2) activities that support objectives, and 3) mathematical conjectures as results of activities. The activities created later are based on geometric thinking at the Van-Heale level on the concept of triangular properties that are in accordance with the student's character. The hypothetical learning trajectory framework of the triangular property is presented in Figure 2.

After the HTL framework was created, the researcher prepared teaching materials and learning guidelines for teachers. Teaching materials and learning guidelines for teachers are prepared based on the learning barriers that have been obtained. Then validated by experts. The following are the results of the validation of teaching materials and teacher study guides which were validated by three mathematics lecturers at FKIP Unswagati and two mathematics teachers at MTs Negeri 1 Majalengka. After teaching material guidelines for teachers have been prepared, these guidelines are then validated by five validators (experts) to determine whether the guidelines are appropriate or not. Input in improving teaching material guidelines for teachers from the five validators. To find out whether the teaching material guidelines for teachers are appropriate or not, a validation test is carried out by marking the validation sheet by five validators. According to Lestari & Andriani (2019) there are four aspects that will be assessed in the module, namely content feasibility aspects, presentation feasibility aspects, language feasibility aspects, and mathematical understanding evaluation aspects.

According to Revita (2017) the validation test was carried out by experts, resulting in the following: the content qualification aspect in this teacher's teaching material guide obtained a score of 91.25%, the presentation qualification aspect in this teacher's teaching material guide obtained a score of 90.83%, the
Before carrying out the implementation of teaching materials to students, the researcher prepared a Learning Implementation Plan (RPP) for two meetings. According to Alhikmah, Roza, & Maimunah (2021) Components of the Learning Implementation Plan (RPP) based on the Ministry of Education and Culture number twenty two consist of school identity, subject names, class descriptions, types of learning materials, time allocation, learning objectives based on basic competencies, what indicators what will be achieved, learning resources, learning methods and models, content, and final assessment of learning. According to Tanjung & Nababan (2018) valid lesson plans, then compile teaching materials to be implemented. In the process of implementing teaching materials, students are first given prerequisite material for the characteristics of the triangle that has been presented in the module, after completing the prerequisite material, students are told the learning objectives to be carried out and motivate these characteristics. triangles in everyday life, such as "that a building with a triangular frame will be stronger, because a triangle has a wide base but tapers upwards, like the pyramids in Egypt, therefore we need to study triangular materials, especially the properties of triangles. Next is given the core material on the properties of triangles starting from the definition of triangles, triangular lines, and triangular inequalities. In this teacher intervention the researcher also provides anticipation that has been done previously so that students do not experience difficulties in learning, then provides responses to student responses beyond predictions when questions are given. Just as the teacher anticipates students' difficulties in using the triangular inequality formula, namely by providing explanations repeatedly -repeat about using the triangle inequality formula. The next anticipation is that students are directed to understand the problem first so that misinterpretation does not occur, and is directed to make conclusions on the results of the answers. At the third meeting, students continued the material presented at the second meeting, namely about the inside and outside angles of triangles, types of triangles based on their properties, and the Pythagorean theorem. In this teacher intervention the researcher also provides anticipation that has been done previously so that students do not experience difficulties in learning, then responds to student responses outside of predictions when given questions. Just as the teacher anticipates students' difficulties in determining the types of triangles and using the Pythagorean formula, namely by giving repeated explanations about the types of triangles and using the Pythagorean formula. The next anticipation is that students are directed to understand the problem first so that there is no misinterpretation. As well as directed to make conclusions on the results of the answers.

Then a respondent's ability test (TKR) was carried out on class VII students for comparison before receiving lessons and after receiving learning about the properties of triangles whether there was an increase as measured by the test. The results of the respondent selection test and the respondent's ability test on students about the properties of triangles indicate
an increase in learning in the material about the properties of triangles. Learning with the design of this teaching material in addition to improving student learning outcomes can also minimize learning barriers in the material properties of triangles. From the design that was made and implemented on the concept of triangular properties there was an increase in mathematical understanding of 57% included in the category of moderate improvement.

CONCLUSIONS AND RECOMMENDATIONS
Based on the results of research and discussion, The didactic design in this study is based on learning obstacles material on the properties of triangles to improve mathematical understanding and the level of thinking of van-hiele geometry in class VII junior high school students of 1 Majalengka: The didactic design of triangular properties was declared valid from several teaching materials based on the results of the questionnaire given to the five validators. the results of the questionnaire from the validator showed an average percentage of module validity of 85.4%, teaching material guidelines for teachers of 89%, lesson plans of 87.3%. The results of the pretest and posttest test scores for class VII students on triangular properties showed an increase in the level of mathematical understanding and the level of thinking of Van Hiele geometry by 57%.

This study recommends to researchers, based on the conclusions and discussion of research results, that a greater improvement is obtained, it is suggested that teaching materials about the properties of triangles based on mathematical abilities and the level of thinking of Van Hiele geometry are more interesting and if necessary make teaching aids for the process of implementing the material teach. In addition, there are still learning obstacles in the material on the properties of triangles after the implementation of the teaching materials is carried out, so it is advisable to overcome these learning obstacles. For future researchers, it is suggested that research on learning mathematics with a didactic design based on mathematical understanding and Van Hiele's level of geometric thinking be carried out in other subjects.

REFERENCES


Books.


