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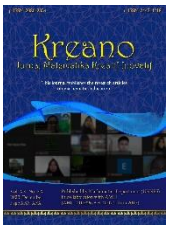

Didactic Design Research on Two-Dimentional Shape Materials Based on Learning Obstacles in Grade VII Mathematics Learning

Widaswara Agustin Hanisyah[1*], Nuriana Rachmani Dewi[1], and Ardhi Prabowo[1]

[1]Universitas Negeri Semarang, Semarang, Indonesia

Correspondence should be addressed to Widaswara Agustin Hanisyah:
widaswar18@students.unnes.ac.id

Abstract

Geometric shapes are a prerequisite for achieving Phase D learning outcomes in the assessment criteria. However, difficulties were observed among Grade VIII at one of Junior High School in Semarang. The students were unable to solve problems related to geometric shapes in contextual or unconventional problems. This indicates that the students are experiencing learning difficulties with geometric shapes. Learning barriers describe the limitations individuals experience in understanding or mastering a concept within a learning topic. Therefore, this study was conducted to analyze students' learning barriers in plane geometry, which will then serve as the basis for developing a didactic design in the form of instructional materials for plane geometry. The research subjects were 8 eighth-grade junior high school students and 1 mathematics teacher. This study employed a qualitative approach using the Didactical Design Research (DDR) methodology, which consists of three stages of analysis: (1) analysis of the didactic situation, (2) metadidactic analysis, and (3) retrospective analysis. This study focused on the analysis of the didactic situation. Learning barriers were analyzed through the results of the respondents' ability tests, interviews, and observations of the learning process. The barriers identified were: a) Epistemological Barriers, where the subjects did not fully understand the concepts of area and perimeter; b) Ontogenetic Barriers, where the subjects did not master the prerequisite material; c) Didactic Barriers, where the learning process only included didactic situations in the form of action situations. The identified learning barriers were subsequently used as the basis for developing a didactic design. The didactic design, developed based on the learning trajectory while considering the identified learning barriers, was then validated by two supervising lecturers and two mathematics teachers from the school where this research was conducted.

Keywords: Didactic Design; Learning Obstacle; Two-Dimentional Shape

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Abstrak

Materi Bangun datar menjadi materi prasyarat untuk mencapai capaian pembelajaran fase D pada elemen pengukuran. Akan tetapi, kesulitan ditemukan pada Kelas VIII di salah satu SMP di Semarang. Peserta didik belum bisa menyelesaikan permasalahan berkaitan materi bangun datar pada permasalahan kontekstual atau permasalahan yang tidak biasa. Ini menunjukkan bahwa peserta didik mengalami suatu hambatan belajar pada materi bangun datar. Hambatan belajar menggambarkan adanya keterbatasan yang dialami individu dalam memahami atau menguasai suatu konsep pada suatu topik pembelajaran. Oleh karena itu, penelitian dilakukan untuk menganalisis hambatan belajar peserta didik pada materi bangun datar yang kemudian akan dijadikan dasar untuk menyusun desain didaktis berupa bahan ajar pada materi bangun datar. Subjek penelitian adalah 8 orang peserta didik kelas VIII SMP dan 1 orang guru matematika. Penelitian ini menggunakan penelitian kualitatif dengan desain penelitian Penelitian Desain Didaktis (Didactical Design Research) yang terdiri dari tiga tahap analisis, yaitu (1) analisis situasi didaktis (2) analisis metapedadidaktik, dan (3) analisis retrosfektif. Penelitian ini berfokus pada tahap analisis situasi didaktis. Hambatan belajar dianalisis melalui hasil tes kemampuan responden, wawancara, dan pengamatan terhadap proses belajar. Hambatan yang ditemukan, yaitu a) Hambatan Epistemologis, subjek tidak memahami konsep luas dan keliling secara utuh, b) Hambatan Ontogenik, subjek tidak menguasai materi prasyarat, c) Hambatan Didaktis, proses pembelajaran hanya memuat situasi didaktis berupa situasi aksi. Hambatan belajar yang ditemukan selanjutnya digunakan sebagai dasar pengembangan desain didaktik. Desain didaktik yang dikembangkan berdasarkan lintasan pembelajaran dengan mempertimbangkan hambatan belajar yang telah diidentifikasi selanjutnya divalidasi oleh dua dosen pembimbing dan dua guru matematika dari sekolah tempat penelitian ini dilakukan.

INTRODUCTION

Mathematics is a tool for global knowledge and communication that helps make our lives more organized. Mathematics helps us understand the world and is an effective way to cultivate disciplined thinking. By studying mathematics, one becomes accustomed to thinking systematically, scientifically, and critically, while also enhancing one's creativity *(Ni'mah & Auliya, 2023; Sharma, 2021; Yohansa, 2018)*. Therefore, mathematics is taught at every level of education, from elementary school to college. This is intended to equip students with these skills in facing various challenges in everyday life.

Kementerian Pendidikan Dasar Dan Menengah (2025) has established mathematics learning outcomes taught in schools consisting of five content elements, namely numbers, algebra, measurement, geometry, and data analysis and probability. Two-dimentional shapes are one of the important prerequisite materials for achieving learning outcomes in phase D of the measurement element, namely "...Students can explain how to determine the surface area and volume of shapes (prisms, cylinders, spheres, pyramids, and cones) and solve related problems." However, in learning, many students still have difficulty understanding two-dimentional shapes.

The difficulties experienced by students in learning two-dimentional shapes include understanding and using essential concepts, difficulty in completing or solving problems thoroughly, difficulty in applying the material in other forms to real objects, difficulty in determining strategies for performing mathematical procedures and difficulty in solving problems in the questions given, interpreting solutions due to a lack of understanding of the questions given, a lack of understanding of mathematical concepts, students' mistakes in solving problems based on conceptual and procedural aspects, and students feeling confused when connecting mathematics material with other material so that they cannot solve problems (Ali et al., 2023; Ubudiyah & Amelia, 2021; Waluyo & Nuraini, 2021). Those problems are found in this research.

Problems with two-dimentional

shape material has found in Grade VIII at one of Junior High School in Semarang. Based on the results of interviews with mathematics teachers at the junior high school, it was said that students were not yet able to solve problems related to two-dimentional shape material in contextual problems or unusual problems.

Based on the results of the two-dimentional shape test, it is evident that students have difficulty solving unusual problems. An "unusual problem" in this context refers to a problem that requires students to first analyze the given information and the question posed regarding problems related to two-dimensional shapes such as triangles and quadrilaterals; it is not a problem that simply involves calculating the area of a triangle or quadrilateral whose side lengths are clearly specified or can be determined from a commonly shown image. It appears that students still make mistakes in determining the height of a parallelogram when the image shown is slightly different from what is commonly shown. This also occurs in problems involving the area of a kite, when the diagonal size is not clearly stated in the question. Students know the formula for the area of a kite, but they are confused about determining the diagonal element of a kite. When working on the problem, students asked the teacher which was the diagonal of the kite.

Another phenomenon was also found, namely that students were mistaken in using the concept of perimeter in combined two-dimentional shapes. It was observed that students calculated the perimeter of each two-dimentional shape and then added them together. Based on interviews with these students, they said that the perimeter is the sum of all sides of a two-dimentional shape. Of course, this will lead to a misunderstanding of the concept of perimeter for students. The perimeter is the length of the outer boundary of a shape. Students did not understand that perimeter is the length of the outer boundary of a two-dimentional shape itself.

Based on the results of the two-dimentional shape test, it was evident that students had difficulty solving contextual problems. Students found it difficult to imagine the situation described in the questions. They were confused about how to apply the concepts they had learned about two-dimentional shapes because they could not understand the questions well. In addition, there are students who are inaccurate in solving problems due to their lack of understanding of the prerequisite material in the form of units. This phenomenon shows that students experience learning obstacles in learning two-dimentional shape material.

Learning obstacles describe the limitations experienced by individuals in understanding or mastering a concept in a learning topic (Brousseau, 2002). According to Brousseau (2002) and Duval (2006), learning obstacles can be caused by several factors, namely ontogenic obstacles (mental readiness to learn), didactic obstacles (due to the education system), and epistemological obstacles (students' knowledge has limited application context).

Ontogenic obstacle occur because the learning process is not in line with the child's readiness. These obstacles are caused by the mental and psychological immaturity of students in accepting new knowledge to replace the old knowledge structure they have (Brousseau, 2002; Marfuah et al., 2023). Didactic obstacles are obstacles that arise due to errors in the learning process, which originate from the structure or mechanism of the education system in schools. This type of

obstacle is solely influenced by decisions or designs established in the education system (Brousseau, 2002). Epistemological obstacles are the limitations of a person's knowledge in a particular context. Epistemological obstacles arise from learners' knowledge that has not been generalized deductively, making it difficult for learners to apply it to all contexts (Brousseau, 2002; Marshall et al., 2021). When faced with a different context, the knowledge possessed becomes unusable, or the learner experiences difficulty in using it. In this case, the learner's view of other concepts becomes fragmented and incomplete.

Identifying the learning barriers students face when understanding mathematical concepts can help them learn mathematics more effectively (Phafiandita et al., 2022). Learning barriers are obstacles that can prevent students from completing the thinking process and understanding a concept (Rosita et al., 2020). Thus, research is needed to thoroughly examine the learning barriers students face in learning mathematics. Various studies have been conducted on learning barriers and instructional designs for topics related to two-dimensional shapes such as triangles and quadrilaterals (Desmayanasari & Hardianti, 2021; Wantah & Prastyo, 2022), including research on students' learning barriers in solving problems involving two-dimensional shapes (Rismawati et al., 2018). However, no previous research has detailed the learning barriers faced by junior high school students regarding the material on two-dimensional shapes (triangles and quadrilaterals) while simultaneously designing a didactic design for that material. A didactic design is a learning plan created based on learning obstacles by fostering interaction between students and the material, enabling teachers to create an ideal didactic situation for students (Aisah et al., 2016; Suryadi & Suratno, 2013).

Based on this description, research is needed to analyse the learning obstacles of learners in two-dimentional shape material. The results of this analysis will then be used as a basis for developing a didactic design in the form of teaching materials on two-dimentional shape material.

METHOD

This study was conducted at a junior high school in Semarang. The study sample consisted of 9 participants, namely 8 eighth-grade students who had studied the geometry of triangles and quadrilaterals, and one mathematics teacher at the school who had taught the students mathematics in seventh grade.

Data for analyzing learning barriers was collected through a series of analyses of respondents' ability test results, interviews, and observations of the learning process. The analysis of respondents' ability test results was conducted prior to interviewing the main subjects. The analyzed test results focused on how the subjects solved problems in the test questions. Interviews with the subjects regarding their answers to the test questions were conducted to further identify the causes of learning barriers among students. Observations of the learning process were conducted to assess the classroom environment, which was subsequently confirmed through interviews with the subjects.

The observed phenomena were analyzed to determine their causes and identify the learning barriers faced by students. The analysis was conducted in the following stages:

This study employs a qualitative research approach, which is a research method aimed at understanding social phenomena or phenomena. The research design used is Didactical Design Research. Data analysis was conducted in accordance with the stages of Didactical Design Research, which consists of three stages: (1) analysis of the didactic situation, (2) metadidactic analysis, and (3) retrospective analysis (Suryadi, 2013). This study focuses on the stages of didactic situation analysis. These research limitations were imposed because the primary objective of the study is to identify learning barriers and design an appropriate didactic design. These limitations were also implemented to ensure the depth of analysis regarding the identification of learning barriers and the design of the didactic design.

The observed phenomena were analyzed to determine their causes and identify the learning barriers faced by students. The analysis was conducted in the following stages Didactic Situation Analysis was conducted by first compiling a test instrument in the form of a Respondent Ability Test (RAT) related to the material on triangular and quadrangular shapes. Next, the respondent ability test was administered to the research subjects. The RAT results were analyzed to identify the learning obstacles experienced by the subjects. Analysis of learning obstacles was also conducted based on interviews with the subjects regarding the RAT results to gain further insight into the RAT process. In addition, analysis was also conducted through observation of the learning process to identify learning obstacles that the subjects might encounter in the learning process. The results of the didactic situation analysis and learning observation were confirmed with the teacher through an interview.

The analysis of the didactic situation to identify learning obstacles was carried out by looking at the stages of action, formulation, validation, and institutionalization, which are the framework of the didactic situation theory to identify learning obstacles. Furthermore, based on the analysis of learning obstacles, a didactic design will be developed as an effort to reduce or overcome the subjects' learning obstacles in the material on triangular and quadrangular shapes. The didactic design that has been developed was discussed with experts for validation testing.

The validation test used a questionnaire consisting of four evaluation aspects, namely: (1) content appropriateness, (2) presentation appropriateness, (3) language appropriateness, and (4) instructional innovation. This validation questionnaire used a Likert scale ranging from 1 to 4. The validation of the didactic design was conducted by four validators, consisting of two supervising lecturers and two mathematics teachers from the school where the research was conducted. The validators assessed the didactic design, specifically the student worksheets on plane figures, which were accompanied by the Teacher's Guide and Instructional Module used in the learning process. The research process can be seen in Figure I.

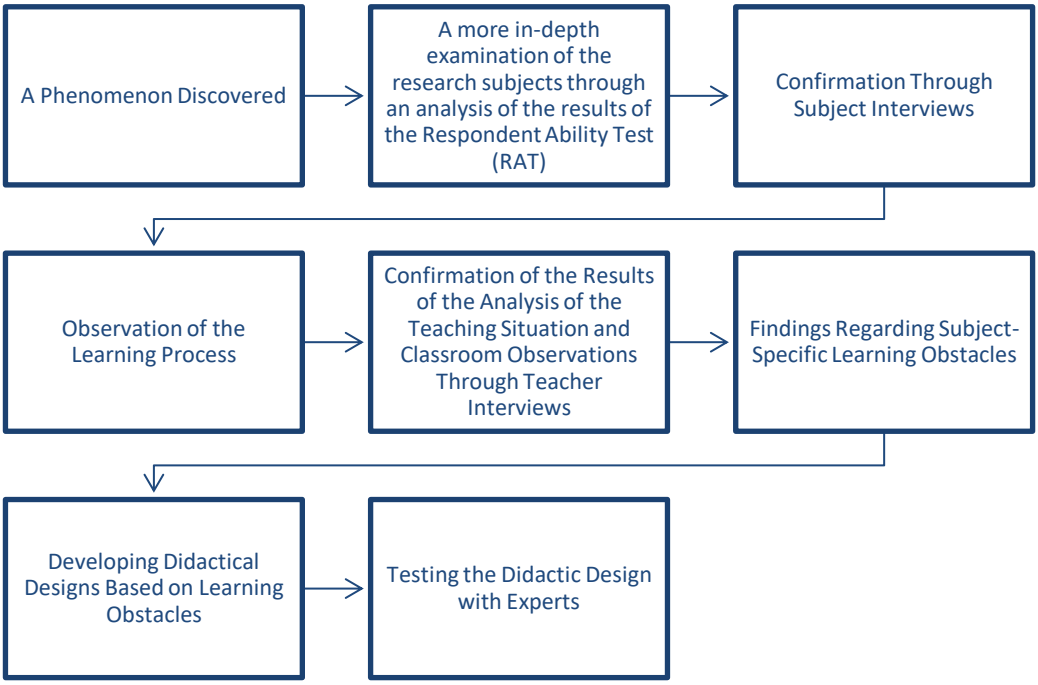

Figure 1. Research Steps

The analyzed data were validated using techniques of credibility, transferability, confirmability, and dependability. Data credibility was tested using the triangulation method (Korstjens & Moser, 2018). Information from the respondents' answers to the ability test questions completed by the research subjects will be explored through interview sessions, while also examining the learning processes experienced by the research subjects. Subsequently, the results of the test analysis and interviews were confirmed with the teachers through interviews.

Data transferability is achieved through an explanation of the research findings, which include students' behaviors and experiences—specifically the learning obstacles they encountered—along with a comprehensive explanation of the context, namely the subject matter being discussed (in this case, plane figures), so that these behaviors and experiences can be fully understood (Korstjens & Moser, 2018; Prabowo et al., 2022). This study will lead to the development of a didactic design for plane geometry material in seventh grade.

Confirmability is achieved by providing documentation that details every step of the data analysis process, thereby establishing a rationale for the decisions made (Korstjens & Moser, 2018). Data reliability was ensured by clearly and comprehensively explaining the research steps taken from the beginning of the study through to the reporting of findings (Korstjens & Moser, 2018; Prabowo et al., 2022).

RESULT AND DISCUSSION

Results

The analysis in this study was conducted in three ways, namely interviews with subjects who were eighth-grade students who took the Respondent Ability Test, interviews with mathematics teachers, and observations of classroom learning. There were eight student subjects, while one mathematics teacher who was interviewed was a mathematics teacher

who taught the subject when the students were in seventh grade.

The interviews with the subjects were conducted for approximately 40 minutes in one session. There were several findings regarding the difficulties faced by the subjects that caused learning obstacles in the material on triangular and quadrilateral shapes. This difficulties caused epistemological and ontological obstacles. The first finding was that the students did not have a good grasp of the properties of triangular and quadrilateral shapes. This was evident in the interview session with the subjects regarding questions related to the properties of shapes.

Subject B

W : What two-dimentional shapes have right angles?
B : Right triangles, parallelograms.
W : Is that all?
B : Yes.

Subject D

W : What two-dimentional shapes have two pairs of parallel sides?
D : Rectangles and parallelograms, but their lines are slanted.
W : What two-dimentional shapes have two pairs of equal angles?
D : Squares, isosceles triangles, parallelograms, and trapezoids.

The second finding is related to the first, concerning the concepts of lines and angles. The subjects were unable to explain well the position of lines (parallel, intersecting, perpendicular) and types of angles.

Subject A

W : What are parallel lines?
A : Lines that go in the same direction.

Subject B

W : What does a right angle mean?
B : For example, take a triangle, but not a perfect triangle.
What shape has two pairs of parallel sides?
W :
B : A rectangle, a square, a parallelogram.
W : How are the sides parallel?
B : The sides are the same size and the same length.

These two findings cause difficulties for students in analyzing two-dimentional shapes whose sizes are not directly mentioned or shown in the questions. In addition, this also causes difficulties for students in distinguishing between one two-dimentional shape and another. Students who do not fully understand the concepts of lines and angles will find it difficult to learn the properties of triangles and quadrilaterals. Furthermore, when students do not understand the properties of two-dimentional shapes well, they will have difficulty remembering the types of two-dimentional shapes that exist. This can be seen in one subject who has an understanding of both concepts; they can understand and analyze two-dimentional shape problems whose measurements are not directly mentioned well. However, they are not yet able to fully explain the reasons why.

Subject A

W : What types of quadrilaterals are studied?
A : Rectangles, squares, rhombuses, kites, parallelograms.
W : What shape is a kite?
A : It's like a kite, ma'am.
W : What about a rhombus?
A : It's similar to a kite, but more like a square?
W : What is the difference between a rhombus and a square?
A : The angles of a square are 90 degrees, while the angles of a rhombus are less than or more than 90 degrees.

W : What are the properties of a parallelogram?
A : I don't know, ma'am, because I didn't study its properties. I only studied its formulas.
W : Are the formulas of other two-dimentional shapes also the only thing studied?
A : Some are studied for both their formulas and properties, and some are studied only for their formulas.
W : Which two-dimentional shapes are studied for both their formulas and properties?
A : Squares, circles, rectangles, and triangles.
W : What are the properties of a rectangle?
A : It has 4 angles, and when folded, it looks like a rectangle with 90-degree angles.
W : Are there any other properties of rectangles?
A : I think there are, but I forgot, ma'am.
W : What about the properties of squares?
A : The ones that stay the same when rotated, what are they called, ma'am?
W : Axis of rotation?
A : Yes, axis of rotation. It has 4 angles, each measuring 90 degrees. That's all I remember, ma'am.

Another finding is that students do not yet understand the elements of two-dimentional shapes themselves, such as height, base, perimeter, and area in general. They only understand them in certain contexts.

Subject A

Question Number 1

W : What is height in a two-dimentional shape?
A : I was taught that height is from top to bottom.

Question Number 3

W : Why did you determine that the height of triangle DEF is 9 cm?
A : Because that height, from top to bottom, is in the middle here.

Question Number 2

W : What is the difference between perimeter and area?
A : Perimeter is the outer lines. Area is the inside.

Question Number 8

Students can answer questions well. Students determine the elements of two-dimentional shapes accurately in determining the area of the two-dimentional shapes in question. The height element for the parallelogram in question 1 was incorrect, but in question 8, the height element for the parallelogram was determined correctly. This is because the two-dimentional shapes presented are commonly used.

Subject B

W : What is the difference between area and perimeter?
B : Perimeter is the sum of all sides, while area is only the base and height.
W : In a two-dimentional shape, which side is that?
B : The side line.
W : Which part is called an angle?
B : The point.
W : Which part is called the perimeter?
B : All of it.
W : Which part is called the area?

B : The base and height.

Subject C

W : Why are you sure that the height is 12 cm and the base is 10 cm?

C : The base is short, and the height is long, ma'am.

W : What about 7 cm?

C : It's the diagonal of the parallelogram, ma'am.

Subject D

Question Number 2

W : How did you determine the perimeter of the two-dimentional shape?

D : It is a combined two-dimentional shape, namely a square and a trapezoid. So I determined the perimeter by adding the perimeter of the trapezoid to the perimeter of the square, Ma'am.

Question Number 3

W : Why did you decide on a height of 9 cm?

D : To determine the height from top to bottom.

Question Number 8

W : Why did you determine the height of the parallelogram to be 10 m? (In the figure, the parallelogram is a commonly displayed parallelogram shape.)

D : Because I took a straight line, ma'am. The height and the slanted line are different.

Question Number 9

W : What concept is applied in this question?

D : In this case, I use my own method, ma'am.

W : The students do not realize that the concept used is the perimeter of a rectangle.

D : What are perimeter and area? Perimeter is the sides, ma'am. Area is the entire inside.

Subject H

Question Number 1

W : What is the difference between circumference and area?

H : Circumference is just the length of the sides, while area is the inside.

W : Why are you sure that the height is 12 cm and the base is 10 cm?

H : Because it can be flipped over, ma'am. I think the base is the short side and the height is the long side.

W : What is the 7 cm measurement?

H : It's the diagonal line, ma'am.

The mathematics teacher interview was conducted with mathematics teachers teaching seventh grade. The interview consisted of one session lasting 30 minutes.

W : What difficulties do students experience when learning about two-dimentional shapes in seventh grade?

R : They have difficulty memorizing formulas. They often confuse one two-dimentional shape formula with another. In addition, they still do not understand the concepts of area and perimeter of two-dimentional shapes. Some students are also not yet proficient in performing calculations, which hinders their learning process. When children are able to perform the arithmetic operations, they are enthusiastic about solving problems. However, if they have difficulty performing the arithmetic operations, they become

unmotivated. Children also have difficulty analyzing contextual problems. They have to struggle to analyze the problems. They are given clues to guide them in understanding the problems.

W : What methods are used in teaching?

R : I use the usual methods, such as discussion, practice questions, and individual practice.

W : What learning resources are used?

R : School textbooks, and for questions, I usually take them from Erlangga books. Sometimes I also show videos from YouTube.

This finding based on learning observation caused didactic obstacles. Learning observations were conducted twice in class VII G. The lessons were conducted by Teacher A and lasted for 3 hours. Mathematics lessons on two-dimentional shapes were conducted in 3 sessions. The first session was conducted at the end of the previous lesson. Teacher A explained the shapes and formulas for the perimeter and area of triangles and quadrilaterals by writing them on the board. Then, Teacher A gave the students a group assignment to prepare tools and materials to make a wall magazine about triangles and quadrilaterals for the next session.

The second session was on Friday, May 16, 2025. The second session began with an introductory activity, which involved preparing the classroom and students, taking attendance, and reviewing the previous material. Teacher A conducted a question and answer session with the students about the shapes of two-dimentional shapes. Next, the main activity consisted of group assignments to create wall magazines containing information on triangular and rectangular shapes, their properties, and the formulas for the area and perimeter of these shapes. Each group consisted of 2-3 students. At this stage, the students were seen drawing two-dimentional shapes by trial and error without paying attention to the properties of the two-dimentional shapes. Three students who were observed in the process of drawing rhombus shapes appeared to have difficulty and drew repeatedly, only guessing whether the shape was in accordance with the rhombus shape they knew. This was also seen in other two-dimentional shapes such as kites, trapezoids, and parallelograms. When the learning time was over, the students had not finished the wall magazine, so the teacher directed them to continue outside of learning time. At the closing stage, the teacher reminded them to finish the wall magazine and announced the learning activity for the next meeting, which was to present the results of the discussion.

The third meeting was held on Thursday, May 22, 2025. The learning activity began with an introductory stage, in which Teacher A prepared the classroom. Teacher A then asked about the wall magazine assignment from the previous meeting. The students reported that no group had finished the assignment. Teacher A instructed the students to continue working on the wall magazine assignment first. Some time later, the teacher asked the groups that were ready to present in front of the class. During the presentation session, the class was not very conducive because not all students were paying attention. Other groups that had not finished the wall magazine were still discussing it and did not pay attention to the groups that were presenting. On the other hand, the presenting groups did not convey the results of their discussions optimally.

Their voices were not very audible, and they only read briefly from the wall magazines they had made. At the end of the presentation, Teacher A did not reinforce the material in the group discussions. Teacher A did not explain again the shapes made by the students. Teacher A also did not discuss the process of drawing the shapes made by the students. After several groups had presented, Teacher A concluded the learning activity by reviewing the types of two-dimentional shapes that exist and the formulas for the area and perimeter of these two-dimentional shapes. Then Teacher A ended the lesson.

Teacher A said that there should be one more lesson on triangular and quadrilateral two-dimentional shapes to discuss example questions and practice questions. However, the next meeting was scheduled for the school exam.

Discussion

Learning Obstacles

Based on the above explanation, it was found that the phenomenon of students having difficulty in solving contextual problems does indeed occur. This can be seen from the results of interviews conducted with Teacher A, the results of respondent ability tests, and the results of subject interviews regarding the respondent ability tests that have been carried out. Through further analysis of the interview results and learning observations, several learning obstacles were found that caused students to have difficulty solving contextual problems.

The first obstacle is an epistemological obstacle. This obstacle is in the form of students' limited understanding of the concepts of area and perimeter in triangles and quadrilaterals. They only memorize the types of plane figures and their area and perimeter formulas. However, they have not yet formed a generalization of the concepts of area and perimeter. The cause is related to didactic obstacles, whereby during the learning process, students are introduced to two-dimensional shapes and their area and perimeter formulas directly, without without being introduced to real situations related to these concepts.

Their understanding of the concepts of area and perimeter of two-dimentional shapes is not strong and comprehensive, so they are unable to imagine the conditions of the existing problems and find it difficult to understand what needs to be solved in questions related to the area and perimeter of two-dimentional shapes.

Based on the results of the respondents' ability tests, students were unable to understand contextual problems regarding the area and perimeter of triangles and quadrilaterals. During the interview session, it was found that students were not aware of the use of the concepts of perimeter and area in solving these problems. This shows that they lack an understanding of the concepts and concrete examples of the use of the concepts of perimeter and area of these two-dimentional shapes.

The second obstacle is an ontogenic obstacle. This obstacle occurs because students do not yet have sufficient prerequisite knowledge about the definitions and the properties of triangles and quadrilaterals, making it difficult for them to distinguish between the two shapes. The reason students have difficulty solving problems related to triangles and quadrilaterals is a lack of understanding of the types of triangles and quadrilaterals, their properties, and their definitions (Rozi Hadiyanto, 2020). Furthermore, students lack an understanding of the concepts of lines

and angles, which are basic materials for learning the properties of two-dimentional shapes. The concept of lines and angles become an important basis for understanding other good mathematical concepts related to the material of geometry, such as rectangular and triangular matter, waking up (Mujahidah Annisa et al., 2018). This obstacle causes students to make mistakes in using the appropriate two-dimentional shape formulas. They only memorize the formulas for each two-dimentional shape. When they forget the formula or the shape displayed is not like the example, they become confused or use the wrong formula.

Van Hiele's theory explains the stages of students' understanding of geometric concepts. Van Hiele's theory states that there are five sequential and hierarchical levels of geometric thinking, namely Visualization, Analysis, Order (Informal Deduction), Deduction, and Rigor (Naufal et al., 2021; Vojkuvkova, 2012). Based on this theory, Armah & Kissi (2019) explain that in elementary school, students tend to move from level 1 to level 2. At level 1, students recognize geometric shapes based only on their appearance, compare them with everyday objects, and classify them. At level 2, students begin to analyze and name the properties of geometric shapes. Then, in junior high school, students are at level 3, which is the stage where they are able to understand the relationship between various types of two-dimentional shapes. At this level, students can formulate meaningful definitions and present informal arguments to support and justify their thinking. However, the students in the study who were already in junior high school had not yet mastered the properties of two-dimentional shapes. In fact, they did not even have a good understanding of basic concepts such as the position of lines and types of angles. The material on the position of lines and angles is necessary to understand the properties of two-dimentional shapes. This shows that there are learning obstacles experienced by students in the form of readiness to learn two-dimentional shapes at the next level.

The third obstacle is a didactic obstacle, which is an obstacle related to the learning process or learning situation planned by the teacher. Didactic obstacle arise from the instructional design implemented in the classroom. Students' difficulty in understanding certain concepts stems from the selection of teaching methods or educational systems that are ineffective for them (Brousseau, 2002). Guy Brousseau's Theory of Didactic Situations describes the development of didactic situations in which students have the opportunity to learn independently and take responsibility for their own learning when provided with the necessary learning resources. According to this theory, there are five phases of the TDS that outline the stages of learning in the development of a learning situation: the devolution phase, the action phase, the formulation phase, the validation phase, and the institutionalization phase (Hortelano & Prudente, 2024).

Additional data used to trace the learning process was in the form of teaching module documents used by Teacher A in delivering material on triangular and quadrilateral two-dimentional shapes. However, these documents were not found. Therefore, data related to the learning process was only collected based on interviews with the Subject, interviews with Teacher A, and direct observation of the learning process.

Based on the interview results, the learning process was carried out using conventional methods. Teacher A explained the types of two-dimentional shapes and the formulas for their area and perimeter. After that, he gave example questions and exercises to the students. This was also in line with the results of the interviews conducted by the subjects. The subject explained that the teacher explained the formulas, then provided sample questions and exercises, and used videos from YouTube several times as learning materials. This learning process did not include didactic situations in the form of action, formulation, and validation.

Based on the observation results, Teacher A conducted learning using the project-based learning model. The project given was an assignment to make a wall magazine containing triangular and rectangular two-dimentional shapes, complete with pictures of two-dimentional shapes and their area and perimeter formulas. This learning process included didactic situations, but only action situations. Students were given a problem in the form of drawing triangles and quadrilaterals. By drawing triangles and quadrilaterals, students must indirectly understand the properties of these shapes in order to draw them correctly. However, the process of drawing based on the properties of these shapes was not given special attention.

Students who are simply given formulas directly without going through a meaningful formulation process, but only through a proof process. Additionally, students who merely draw without paying attention to the properties of two-dimensional shapes only undergo an unstructured exploration process and miss the proof stage necessary to fully understand those properties. The absence of formulation and validation in this learning process causes students to view mathematical concepts as separate parts, and they will have difficulty integrating these concepts. The separation between exploration and proof activities in geometry class can create obstacles to students' understanding when connecting one concept to another (Aaron & Herbst, 2019).

The situations and series of situations created by educators certainly have an impact on the students' thinking process, both in terms of meaning, the emergence of mental actions, the construction of thought processes, the acquisition of understanding, the validation of understanding, and the reinforcement of understanding (Suryadi, 2019). A didactic situation is a specifically designed learning context or condition (often in mathematics) to trigger mental interaction between learners and the material (Fitria Larasati et al., 2020; Prabowo & Juandi, 2020). Therefore, if a learning process does not include didactic situations or if the didactic situations do not work well, it can cause didactic learning obstacles.

Suryadi (2019) explains that the learning process does not always go according to plan. The stages between didactic situations or classroom presentations do not always match the needs and circumstances of the students. According to van Hiele's theory, in junior high school, students begin to understand the relationships between types of two-dimentional shapes. They create meaningful definitions and begin to analyze the interrelationships between the properties of two-dimentional shapes, such as squares as a type of rectangle (Armah & Kissi, 2019). However, in the learning process carried out by Teacher A, there were no stages that discussed the interrelationships between the properties of these two-dimentional shapes. As a

result, there was a knowledge gap for students in recognizing triangles and quadrilaterals as a whole. The summary of the results of the identification of these learning obstacles is summarized in the following table 1.

Table 1. Summary of Learning Obstacles Identification Results

No	Types of Obstacles	Obstacles That Occur
1.	Epistemological Obstacle	• The subject does not fully understand the concepts of area and perimeter of triangles and quadrilaterals, but only memorizes the names of shapes and the formulas for their area and perimeter.
2.	Ontogenic Obstacle	• The subject does not master prerequisite material such as the position of lines and angles • The subject does not master the properties of each two-dimentional shape.
3.	Didactic Obstacle	• The learning process only includes didactic situations in the form of action situations. • The learning process does not include stages that discuss the interrelationships between two-dimentional shapes.

Didactic Design

Based on this learning trajectory, a task design was developed that includes tasks supporting the development of students' knowledge. This task design contains task descriptions and explanations of the didactic situations included in them. The task design can be found in Appendix A. The tasks listed in the task design are organized into a complete worksheet for the topics of triangles and quadrilaterals. To provide a clear structure for users of the didactic design, a Teaching Module was developed to ensure focused and effective instruction.

Based on the results of the respondents' ability tests, the students have not yet mastered the properties of squares and triangles. However, according to Van Hiele's Theory—which describes five sequential stages in students' understanding of geometry—students must go through several stages to understand geometric concepts. These stages begin with Level 1: Visualization, where students identify shapes based on their overall appearance without understanding their properties. Level 2: Analysis, where students focus on properties and can classify shapes based on those properties, but do not see the relationships among them. Level 3: Sequencing (Informal Inference), students understand the relationships between properties. These ontogenetic barriers are overcome by incorporating material on the concepts of lines and angles, as well as the properties of two-dimensional shapes such as triangles and quadrilaterals, into a learning pathway designed to strengthen memory.

Based on the results of the respondents' ability tests, students were unable to understand contextual problems involving the area and perimeter of two-dimensional shapes such as triangles and quadrilaterals. When first teaching perimeter and area, teachers should explain these two concepts to students using concrete materials or examples from daily life, rather than simply providing the formulas (Yilmaz & Demir, 2021). This aligns with the stages of learning according to Brunner's learning theory (N. R. Dewi et al., 2025), namely (1) the Enactive Stage (concrete), (2) the Iconic Stage (semi-

concrete), and (3) the Symbolic Stage (abstract). This epistemological obstacle is overcome by introducing the concepts of perimeter and area of two-dimensional shapes—triangles and quadrilaterals—using concrete examples of how these concepts are generally applied to students before they derive the formulas for the perimeter and area of each specific shape.

Based on the results of interviews and classroom observations, the instruction on triangles and quadrilaterals delivered by teachers in the classroom did not include a complete didactic situation; it only included an action-based situation. The learning process also did not include a discussion of the interrelationships between the properties of plane figures, which, according to Van Hiele's Theory, should constitute one of the sequential levels in students' geometric understanding. This didactic obstacle was addressed by designing a complete and comprehensive didactic situation consisting of action, formulation, validation, and institutionalization at each stage of the previously designed learning trajectory. Additionally, a discussion on how the properties of quadrilaterals are interrelated was incorporated. The didactic design is structured by considering the subject's learning obstacles, beginning with the development of a learning trajectory as shown in Figure 2 below.

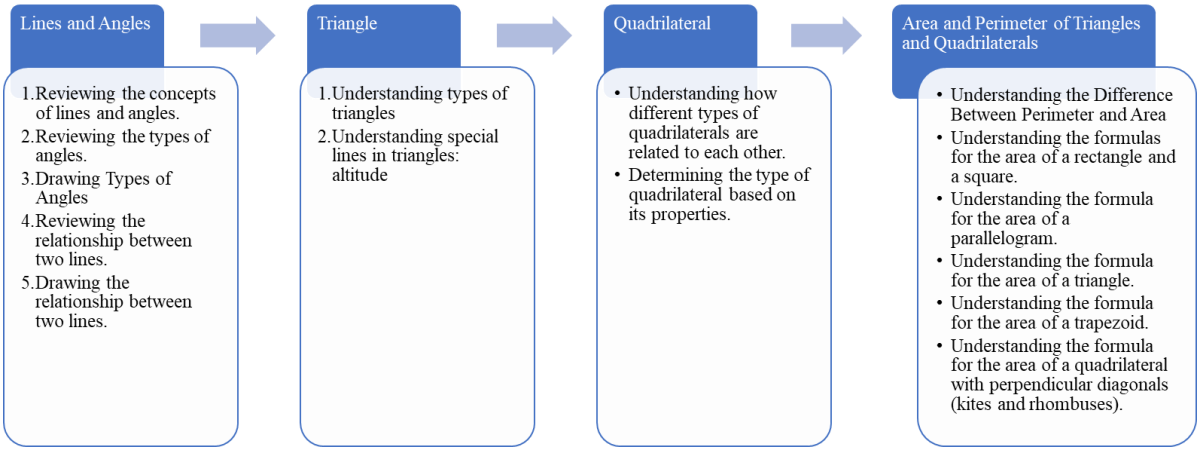

Figure 2. Learning Trajectory: Building Triangles and Quadrilaterals

Based on this learning pathway, a series of tasks was designed to support students' knowledge development. The tasks were compiled into a comprehensive set of student worksheets covering material on triangles and quadrilaterals. Figure 3 (a) shows the cover page of the developed Student Worksheets. In addition, a Teacher's Handbook has also been prepared, containing instructions for teachers on how to conduct the learning process regarding two-dimensional triangles and quadrilaterals using the Student Worksheets. Figure 3 (b) shows the cover of the developed Teacher's Handbook.

(a) (b)

Figure 3. (a) Cover of the Student Worksheet; (b) Cover of the Teacher's Handbook

The Students Worksheets contains three main components, namely comics, tasks, and actions. The comics component consists of reading materials containing material related to the tasks presented in the form of comics or picture stories. This aims to enable students to understand the material in a relaxed atmosphere through stories from comic characters while still leading to an understanding of the material to be learned. Comics are an innovative learning strategy that can simplify complex mathematical concepts through engaging visuals and everyday language. The combination of colors, images, and entertaining storylines has proven effective in fostering a positive learning environment and improving student learning outcomes (Maulidia et al., 2024; Nathasia Subroto & Qohar, 2020). Figure 4 shows Comic Elements in Student Worksheets.

The action component contains actions that must be carried out by students so that they are involved in the process of solving problems and thus experience the learning process directly. The task component contains the main topics of discussion of the material on Triangles and Quadrilaterals, which are arranged in order based on the designed Learning Trajectory. In each task, there are various action components to help students understand the material well. In order to provide a clear structure for users of didactic design, Teaching Modules have been developed for focused and effective learning.

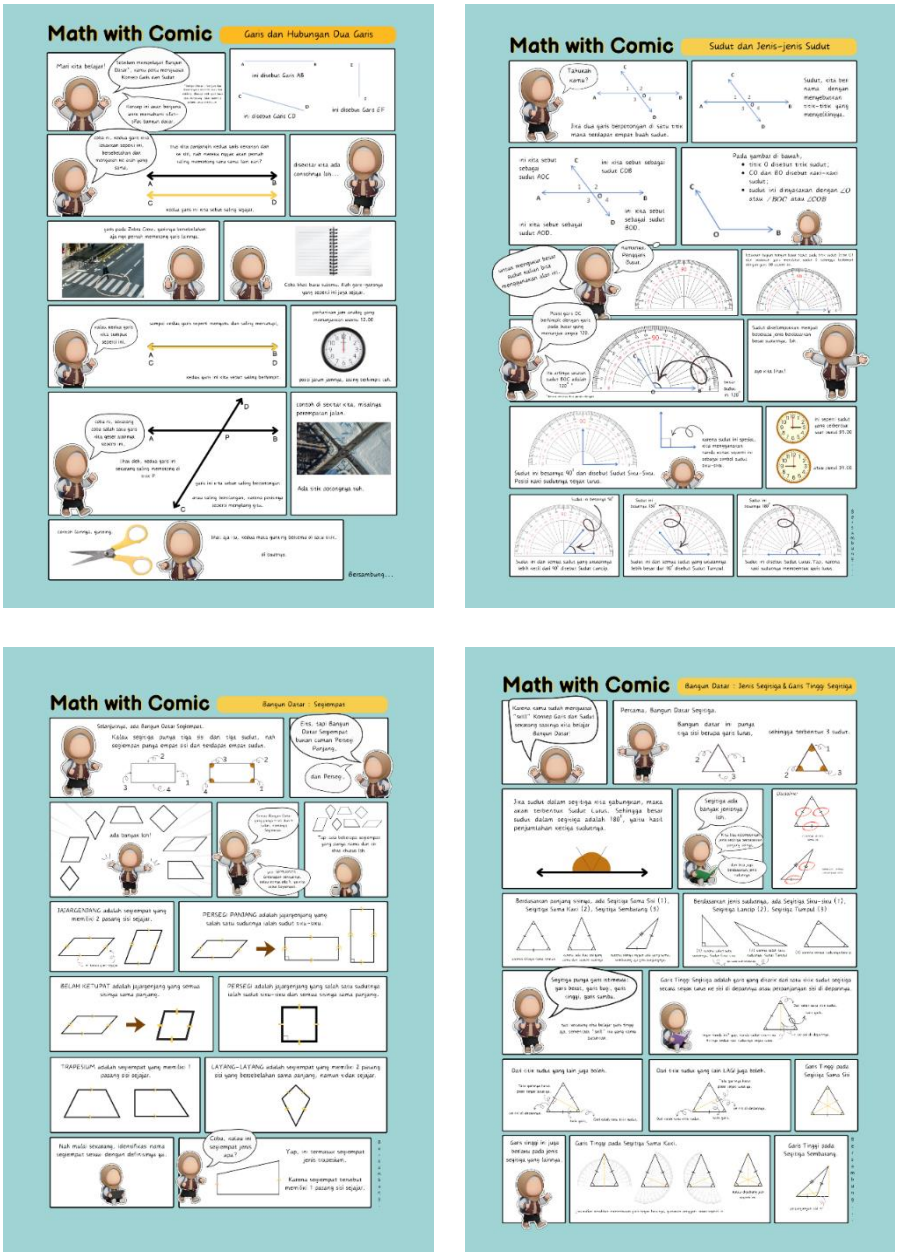

Figure 4. Comic Elements in Student Worksheets

The teaching module on two-dimentional shapes, triangles, and quadrilaterals is designed for three sessions, each lasting two hours. The first session will begin with prerequisite material on lines and angles, covering the following topics: reviewing the concepts of lines and angles, reviewing the types of angles, drawing different types of angles, reviewing the relationship between two lines, and drawing the relationship between two lines. The second session continues with core material on triangles, with detailed tasks, namely recognizing types of triangles and recognizing special lines in triangles: altitude lines. The third session discusses core material on the perimeter and area of quadrilaterals. The teaching module is designed using the Reciprocal Teaching learning model, a contextual approach, as well as discussion, question and answer, and assignment methods.

Implication

Based on the results of the research and discussion, the implications that can be applied in mathematics learning are as follows: 1) Mathematics teachers can use the didactic design of Triangular and Quadrilateral Two-dimentional Shapes as an alternative teaching material design in order to achieve maximum results in learning Triangular and Quadrilateral Two-dimentional Shapes. 2) The use of teaching materials should be adjusted to the students' ability to receive lessons. The number of meetings can be adjusted while still following the sequence of material. Implications for future research include continuing the analysis in metadidactic phase and retrospective phase, specifically by implementing a didactic design and making improvements based on findings from the implementation phase.

Limitation

Some limitations in this study are as follows: 1) This study only conducted an analysis at the di-dactic situation analysis stage. Therefore, further research is needed to analyze further at the metapedagogical stage, namely implementing the initial didactic design that has been compiled. Then, analyze the situation from various responses when the initial didactic design is implemented. This will lead to the retrospective stage, which is an analysis conducted by linking the results of the hypothetical didactic situation analysis with the results of the metapedagogical analysis. 2) This didactic design was created to overcome the learning obstacles experienced by students at SMP Negeri 13 Semarang in the subject of Triangles and Quadrilaterals. Therefore, it is possible that other obstacles that were not previously found will arise when tested on different objects. For this reason, it is recommended that further research be conducted to refine this didactic design.

CONCLUSION

Based on the results of the research and discussion, the following conclusions were drawn: 1) There are three obstacles found in seventh grade junior high school students in the subject of Triangles and Quadrilaterals, namely a) Epistemological Obstacles, where subjects do not fully understand the concepts of area and perimeter of triangles and quadrilaterals, but only memorize the names of the shapes and the formulas for their area and perimeter. b) Ontogenic obstacles: the subjects did not master the prerequisite material, such as the position of lines and angles, and did not master the properties of each two-dimentional shape. c) Didactic obstacles: the learning process only included didactic situations in the form of action situations and did not include stages that discussed the interrelationships between the properties of two-dimentional shapes. 2) The didactic design to reduce learning obstacles for seventh-grade junior high school students in the subject of Triangles and Quadrilaterals was developed based on a learning trajectory that took into account the identified learning obstacles. The didactic design took the form of a Student Worksheet (LKPD) consisting of three main components, namely a comic component, a task component, and an action component. It is hoped that the development of this didactic design will reduce the learning obstacles experienced by these students and assist teachers in the learning process regarding the topics of triangles and quadrilaterals, with adjustments made to accommodate the students' specific circumstances.

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