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THE EFFECTIVENESS OF HYPOTHETICAL LEARNING TRAJECTORY ON QUADRILATERAL TOPICS FOR JUNIOR HIGH SCHOOL STUDENTS

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ABSTRACT

Geometry is an essential topic things to needs to be mastered by participants, one of the topics on geometry is quadrilateral. However, in conditions in the field students Still have difficulty understanding quadrilateral topics. Research This aims to design Hypothetical Learning Trajectory (HLT) Quadrilateral Topics for Grade VII Junior High School Students according to with needs of students and appropriate with the process of thinking student with analyze the effectiveness of HLT applied. The method used in the study This is method design research consisting of three stages : (1) preparation experiment to design HLT (2) design experiment that implements HLT which has been designed, and (3) analysis retrospective that analyzes effectiveness HLT applied in learning. Deep data collection techniques study this : (1) Interviews with teachers and students, (2) Observation and observation, and (3) Documentation For analysis and clarifying HLT. Subject study This consists of 20 students of SMPN 2 Cimahi Class VII with characteristics of heterogeneous students with high, medium, and low ability. This article serves results at stage preparation experiment, design experiments, and analysis retrospective as well as analyze HLT material effectiveness quadrilateral. Track design Study includes, objectives learning material quadrilateral, activities and tasks designed learning For material quadrilateral, and hypothesis channel think a student in understanding draft material quadrilateral. The study This produced HLT which consists of a series of activity learning material rectangle on indicator understand properties quadrilateral, and find around quadrilateral. Analysis results show that HLT is designed in study This Still needs development For activities on the topic properties square, but gives change positive to student class VII in understanding draft around quadrilateral. Analysis results effectiveness reviewed from completeness Study produced by 85% of studes Already achieve KKM on the material quadrilateral, thing This show that the HLT was designed Already effective applied in learning.

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INTRODUCTION

Mathematics learning that tends to be abstract is one of the difficulties for students in learning mathematics. To overcome these difficulties, learning facilities are needed that are in

accordance with their needs. Therefore, teaching methods, teaching materials and learning media as well as learning environments need to be adjusted to students' needs. So it is very important for teachers to design the right learning design by paying attention to the learning flow according to students' thinking abilities (Lantakay et al., 2023). Hypothetical Learning trajectory is a learning design that refers to predictions of how students will learn or develop an understanding of a particular concept during the learning process. HLT This includes hypotheses about the development of students' thinking skills and understanding during learning, which are the basis for selecting models, teaching strategies, materials, and assessments that are appropriate to the stages of students' thinking (Güven Akdeniz & Argün, 2021). Hypothetical Learning trajectory provides guidance for teachers in determining learning objectives to be achieved by students and to achieve learning objectives by designing learning steps based on students' initial abilities.

Geometry is one of the topics that must be mastered by students. Mathematics has many topics of material, one of the most important topics in mathematics is quadrilaterals, but in the field, students still find it difficult to solve mathematical problems in the concept of quadrilaterals, including students having difficulty distinguishing the formula used whether using the area or perimeter formula of a quadrilateral (Amelia et al., 2021). As stated by (Putra et al.,2016) quadrilateral topic is basic material in mathematics, but there are still many students who have difficulty solving problems related to the quadrilateral topic because students have not been able to distinguish the properties of various types of quadrilaterals. Quadrilateral topic is one of the topics from geometry in grade VII mathematics lessons, the topic is often considered difficult by some students because some students find it difficult to calculate area and circumference (Niana & Yusliana Ekawati, 2016). Quadrilateral topics are basic for studying the next topics. However, students still find it difficult to understand the concept of quadrilateral material, if the mastery of quadrilateral topics is still lacking, students will find it difficult to learn the next material. Therefore, the concept of quadrilateral material must be considered and mastered so that students can understand And to obtain meaning with self-knowledge through everyday life experiences (Kadarisma et al., 2020). Saviour (2018) stated that students do not understand the concept of flat building material so that students find it difficult to solve problems that link problems to other materials, and procedural errors found by students are still unable to solve problems in a structured manner and do not understand the problems in story problems. This is in line with the opinion of (Bahan et al., 2018) that the mistakes made in solving problems are when students compile steps in solving problems, especially in descriptive problems in the form of stories related to everyday problems makes students confused And laziness read and understand the questions that look long. Likewise with the problems that researchers found in the field, based on the results of interviews with mathematics teachers at SMPN 2 Cimahi, students' difficulties in geometry topics are still relatively high. Student's difficulties in identifying the types and properties of quadrilaterals and students tend to memorize the formulas for the circumference and area of quadrilaterals but do not understand the definition and meaning of the circumference and area of flat shapes, so students do not understand the basic concepts of the material.

Therefore, the researcher aims to design and analyze a hypothetical learning trajectory. so that it can describe the sequence of learning that must be taken, through the assumption of the level of student thinking to achieve learning objectives in the quadrilateral material. Through the designed activities, students can easily understand the concept of quadrilateral material. There are three main components of a Hypothetical learning trajectory, namely: learning goals, learning activities, and the hypothetical learning process of students (Fonger et al., 2020). Hypothetical Learning Trajectory has the potential to enhance students' understanding of learning, facilitate the use of more effective teaching strategies, and support the

development of better curriculum and design standards (Risdiyanti et al., 2019). According to (Ivana Hendrik et al., 2020) Hypothetical Application learning trajectory in learning is able to improve students' mathematical thinking skills and make it easier for students to understand mathematical concepts (Fauzan et al., 2020). Thus, the Hypothetical Learning trajectory is a series of learning activities/flows designed with more effective teaching strategies to overcome the challenges faced by students, thereby encouraging the development of their thinking in order to achieve learning goals (Güven Akdeniz & Argün, 2021). Hypothetical The learning trajectory in the research is the learning goals of the quadrilateral material on the concept of quadrilateral properties and the perimeter of quadrilaterals, learning activities designed on the quadrilateral material, and the student response hypothesis (hypothetical learning process) in understanding the concept of quadrilateral material.

METHOD

The method used in this research is the design research method which consists of three stages (Gravemeijer & Cobb, 2006): (1) experimental preparation, (2) experimental design, and (3) retrospective analysis. Data collection techniques in this research: (1) Interviews with teachers and students, (2) Observation, and (3) Documentation to analyze and clarify hypotheticals. learning trajectory (learning trajectory hypothesis). The data analysis technique in this study is qualitative analysis, which is based on the results of data collection including student assignments, interview results, documentation of the learning process, and observation notes from experimental design trials. The collected data is then analyzed (Astuti & Wijaya, 2021). The HLT design is compared with the results of data analysis from actual learning experiences to get an idea of how students build their understanding of the quadrilateral material. Based on the data analysis, the HLT is adjusted to the development of students' thinking processes that are revealed during learning. The learning trajectory design includes learning objectives for quadrilateral material, learning activities and tasks designed for quadrilateral material, and hypotheses of students' thinking flow in understanding the concept of quadrilateral material. In this study, the Hypothetical learning trajectory consists of a series of learning activities on quadrilateral material on the indicators: understanding the properties of quadrilaterals and finding the perimeter of quadrilaterals. Subject in study This namely 20 grade VII junior high school students at SMPN 2 Cimahi.

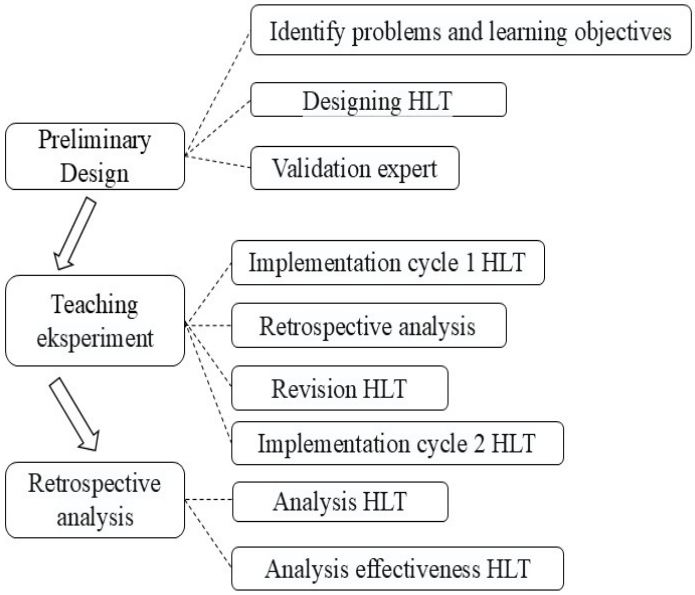

Figure 1. Stages Study

RESULTS AND DISCUSSION

Result

Stage One: Experiment Preparation

The first stage is the stage where researchers conduct literature reviews and interviews with subject teachers so that researchers can understand the characteristics and abilities of students, find out the problems faced by students in the quadrilateral material, and the learning strategies used by teachers in the classroom for the quadrilateral material. Problem identification is carried out so that researchers can design a hypothetical learning trajectory according to student needs (Pratiwi et al., 2020). Furthermore, researchers identify learning objectives in the quadrilateral material and create a Hypothetical Learning Trajectory (HLT) design or a series of learning activities according to student needs in order to achieve the learning objectives of the quadrilateral material. Based on the data obtained previously, in this first stage the researcher used the independent curriculum according to the curriculum in effect at SMP Negeri 2 Cimahi which aims to design HLT using the independent learning curriculum in class VII. The learning trajectory design includes determining teaching materials, learning objectives, and indicators learning (Surya & Aman, 2016), the topic of the material in this study is the concept of the properties of quadrilaterals and the perimeter of quadrilaterals.

The following are the results of an interview with a mathematics subject teacher at SMPN 2 Cimahi:

R	:	How are students' abilities in the quadrilateral material?
T	:	Students are able to perform basic calculations such as calculating the circumference and area of various types of quadrilaterals, but are still limited to memorizing formulas, and still have difficulty in applying more complex formulas or situations that require critical thinking, such as solving story problems related to the application of the concept of circumference and area of quadrilaterals .
R	:	What are the students' difficulties with the quadrilateral material?
T	:	Students often make mistakes in applying the circumference and area formulas due to a lack of in-depth understanding or due to the inability to correctly identify the type of quadrilateral, and difficulty visualizing the shape of a quadrilateral in more complex situations or in story problems.
R	:	What kind of learning do you usually apply when teaching quadrilaterals?
T	:	Learning that is usually applied in class with group work and discussing questions to improve their understanding through collaboration and learning from classmates.

Figure 2. Interview with Mathematics Teacher

Based on the problem conditions that occur in the field for students regarding understanding and difficulties in the material on quadrilaterals based on the results of the interview, it can be concluded that students still tend to memorize the area and circumference formulas without understanding the basic concepts of the area and circumference of the quadrilateral, so that students have difficulty when working on more complex questions. In line with the findings (Fitri & Prahmana, 2018) Students' errors in solving the area and perimeter of a quadrilateral problem are caused by students forgetting the formulas for the area and perimeter of a quadrilateral. To overcome this, the researcher then designed a Hypothetical Learning Trajectory for the topic of the perimeter of a quadrilateral which is shown in Figure 3:

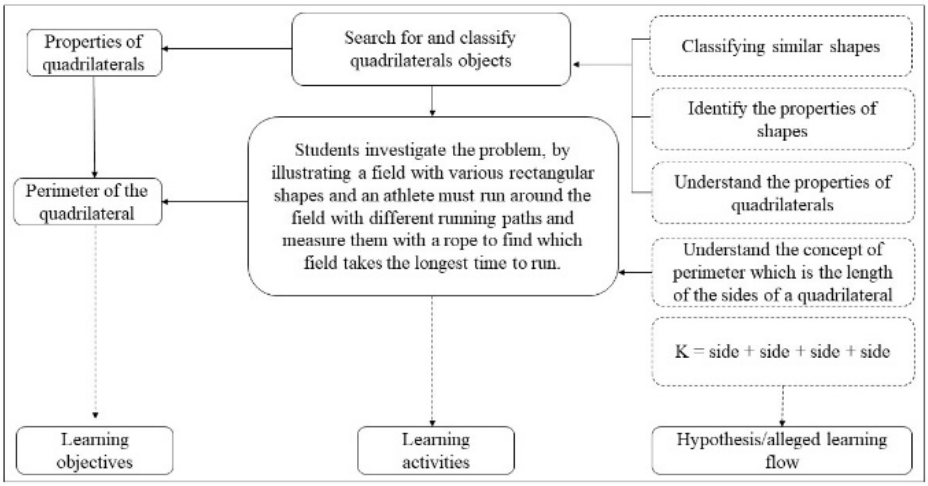

Figure 3. Hypothetical Learning Trajectory

Stage Two: Experimental Design (HLT Implementation)

At this stage, learning is carried out by the teacher in accordance with the HLT that has been designed by the researcher at the preparation and design stage with the aim of investigating students' responses in understanding the concept of the perimeter of a quadrilateral through learning activities and hypotheses of students' thinking patterns that have been predicted in the HLT. In its implementation, the researcher focuses on observing activities and events and analyzing students' thinking processes during the teaching and learning process. ongoing. The implementation of this experimental design involved 20 students with high, medium, and low levels of understanding. The material began with the teacher explaining and introducing media related to the material to be studied. The teacher grouped 20 students into study groups according to their level of understanding. Then distributed teaching aids in the form of flat-shaped objects with various shapes as learning media, then the teacher explained to the students according to the designed HLT. In this activity, students in each group discussed and completed the Worksheets provided. Furthermore, representatives from each group presented the results of the discussion in front of the class.

Figure 4. HLT implementation

Hypothetical Implementation Learning trajectory of the quadrilateral material on the topic of quadrilateral properties and quadrilateral perimeter went well, students were active and enthusiastic in participating in learning activities, so the teaching and learning process became more interesting and interactive. In line with the (Ramadhan et al., 2022) hypothetical findings learning trajectory can help teachers prepare interesting learning and make it easier for students to understand the material. In learning, students can build their own knowledge and find the concept of properties and formulas for the circumference of a quadrilateral independently through activities carried out based on the designed HLT. This is also stated by (Wijaya et al., 2021)through hypothetical learning trajectory teachers can analyze student responses in learning so that the activities designed are by student needs and make it easier for students to understand the concept so that the expected learning objectives are achieved. Activities carried out in hypothetical This learning trajectory is as follows:

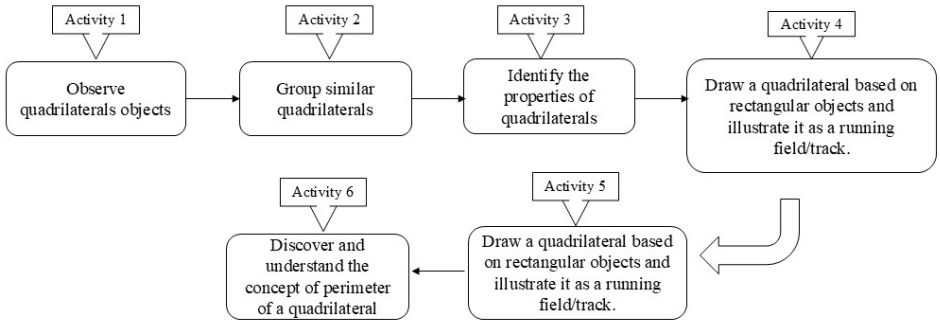

Figure 5. Learning Activities

The activity was evaluated by comparing the HLT that had been designed with the implementation results that had been applied and then analyzed through retrospective analysis.

Stage Three: Retrospective Analysis

At this stage, the researcher compared HLT with the learning process before and after based on the data obtained. To see students' mathematical thinking skills in learning quadrilateral material through analysis of student learning completeness. The data analysis technique used was qualitative data analysis by paying attention to the results of data collection carried out and then comparing the results of observations during the learning process with the HLT that had been designed. Several analyzes obtained from data collection at the HLT implementation stage in the form of interview results, observations and documentation in the form of photos and videos (Moanoang et al., 2021). Hypothetical The Learning Trajectory produced by researchers in this study consists of 6 activities. In each activity, findings were obtained, in the activity of identifying the properties of quadrilaterals, there were still students who had difficulty in linking the similarities and differences in the properties of rectangles and parallelograms, as well as rhombuses and kites. As the findings of (Maulina et al., 2023) students' difficulties in understanding the properties of quadrilaterals due to the lack of students in mastering the prerequisite material, students were still confused in recognizing the types and shapes of quadrilaterals. So researchers will design hypothetical advanced learning trajectory to develop learning flow on the topic of quadrilateral properties. The results of the analysis show that the HLT designed in this study still needs development regarding hypothetical learning trajectory for activities on the topic of properties of quadrilaterals.

However, in the activity of calculating the running track with a square, rectangle, parallelogram, kite, rhombus, and trapezoidal field shape, it helps students build their knowledge in finding the concept and formula for the circumference of a quadrilateral. The activities applied at this stage help students construct the discovery of the concept of the circumference of a quadrilateral, so that they can grow students' analytical skills and mathematical thinking skills with the concept of discovery applied. This is in line with(Larsen, 2013) hypothetical learning trajectory is a learning step that is carried out to find a concept. (Cárcamo et al., 2019)in his research he revealed that hypothetical learning trajectory can construct students in finding concepts. The results of the retrospective analysis show a hypothetical learning trajectory designed to provide positive changes to grade VII students in understanding the concept of the perimeter of a quadrilateral. This is also reinforced by the results of the analysis of student completion in the quadrilateral material, as follows:

Table 1. Student Grade Data

No	Student	Mark	Criteria
1	S-1	82	Completed
2	S-2	75	Completed
3	S-3	80	Completed
4	S-4	68	Not Completed
5	S-5	85	Completed
6	S-6	78	Completed
7	S-7	75	Completed
8	S-8	82	Completed
9	S-9	80	Completed
10	S-10	78	Completed
11	S-11	83	Completed
12	S-12	65	Not Completed
13	S-13	80	Completed
14	S-14	78	Completed

Based on the data presented in Table 1. it can be seen that the number of students whose scores are above 70 exceeding the Minimum Completion Criteria (KKM) is greater than the number of students who are still below the KKM. The following is a recapitulation of student completion from 20 SMPN 2 Cimahi Class VII students on the quadrilateral material:

Table 2. Recapitulation of Completion

Criteria	Amount	Percentage
Completed	17	85%
Not Completed	3	15%

The percentage of students who completed exceeding the KKM of 85% is greater than the percentage of students who have not completed it by 15%. The Hypotetical Learning Trajectory that was designed plays an important role in constructing students' knowledge on the material of quadrilaterals so that it can make it easier for students to understand the material. This shows that the Hypotetical Learning Trajectory Learning Trajectory is effective to be applied in learning quadrilateral material. Based on the results and discussions that have been described, it is concluded that the Hypothetical Learning Trajectory produced in this study can be used as an alternative frame of reference for teachers in designing a series of learning activities that support the development of students' mathematical thinking skills in

quadrilateral material, especially on the topics of quadrilateral properties and quadrilateral perimeter.

Discussions

This study aims to analyze the effectiveness of Hypothetical Learning Trajectory (HLT) on the topic of quadrilaterals for junior high school students. The results of the analysis show that the application of HLT has a significant positive impact on students' conceptual understanding and mathematical reasoning abilities on the topic of quadrilaterals. And HLT is effectively applied to students as seen from the achievement of learning on the topic of quadrilaterals based on student learning completeness. HLT with a structured learning sequence and anticipation of students' thinking processes has proven effective in building a deep understanding of the properties of quadrilaterals and the concept of the perimeter of a quadrilateral. Students who learn with HLT show better abilities in identifying, classifying, and explaining the relationships between various types of quadrilaterals. This is in line with (Simon, 1995) who stated that HLT helps students to build connections between different mathematical concepts and develop a more coherent understanding. So that students can find concepts in the activities carried out.

HLT for this quadrilateral topic can encourage students to be actively involved in learning, so that learning is more meaningful and can develop students' critical thinking skills and geometric reasoning abilities. Students who learn with HLT can apply their knowledge of quadrilaterals to solve complex and varied problems. As stated by (Clements & Sarama, 2004), HLT provides a framework for designing challenging and relevant problem-solving tasks for students. Through the tasks that are worked on, students' mathematical thinking skills are further developed. However, in addition to student activities in learning based on HLT, in order for the results to be more effective, the role of the teacher is also very important in the implementation of HLT. Teachers need to have a deep understanding of HLT and be able to adjust learning to the needs of each individual student. Teachers must also be able to facilitate productive class discussions and provide constructive feedback to students. In line with the opinion of (Bakker, 2018) who stated that effective teachers are teachers who use HLT as a tool to monitor and support the development of students' mathematical thinking.

The results of this study indicate that HLT is an effective learning alternative to improve the quality of quadrilateral learning in junior high schools. Mathematics teachers are encouraged to adopt HLT in their learning practices and continue to develop their understanding of HLT. This quadrilateral HLT can also be an alternative for teachers in overcoming students' difficulties in learning the topic of quadrilaterals. According to (Webel & Platt, 2016) the implementation of HLT can help overcome the difficulties faced by students in learning geometry and increase their interest in mathematics. Further research is needed to investigate the effectiveness of HLT on other mathematics topics and at different levels of education. Research is also needed to explore the factors that influence the effective implementation of HLT in the classroom.

CONCLUSION

Based on the results and discussions that have been described, it was concluded that Hypothetical Learning Trajectory is effectively applied in learning quadrilateral material and can be used as an alternative or reference framework for teachers to design a series of learning activities that support the development of students' mathematical thinking skills in quadrilateral material on the topic of quadrilateral properties, and quadrilateral perimeter. The activities designed can help students find and build their own knowledge, making it easier for students to understand the concept of quadrilateral properties, and perimeter. The results of the retrospective analysis show that there is still a need for development for hypothetical

learning trajectories in the activity of finding quadrilateral properties and providing positive changes to grade VII students in understanding the concept of perimeter and area of quadrilaterals . Another future challenge is teacher competence in developing learning trajectories that are in accordance with students' thinking stages. In this case, there are important aspects that need to be considered, including teacher knowledge of mathematics, teacher knowledge of mathematical activities, teacher knowledge of teaching mathematics, teacher knowledge of student learning on certain topics, and also the teacher's ability to hypothesize student thinking processes, knowledge and analyze student learning difficulties and obstacles in learning mathematics

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