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LEARNING TRAJECTORY DESIGN USING PROBLEM-BASED LEARNING (PBL) ON THE MATERIAL OF SURFACE AREA AND VOLUME OF PRISMS

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Abstract

This type of research is design research, namely research that focuses on developing theories and learning activities. This research aims to design a learning trajectory on the surface area and volume of prisms using PBL and its application in learning using PBL. The research was carried out at SMP Negeri 2 Larantuka in 2023 on 12 students in class VIII b and 16 students in class VIII a. This research was carried out in accordance with the stages proposed by Gravemeijer & Cobb, namely the preparation stage (preparing for the experiment), the research stage (design experiment) and the retrospective analysis stage (retrospective analysis). The results obtained are that the design of a learning trajectory for surface area and prism volume material using the PBL model is theoretically able to facilitate the discovery of the concepts of surface area and prism volume for class VIII SMP students. The learning process also contains PBL steps, namely orientation, organization, guiding individual and group investigations, developing and presenting work results, analyzing and evaluating.

Keywords: Learning Trajectory; Problem Based Learning; Prism

INTRODUCTION

Enhancement of quality learning mathematics done Not only Because need for knowledge of mathematics and the roles mathematics in life every, but to increase of the ability students in mathematics. By studying mathematics, students will trained to think in a way logical, analytical, systematic, critical, creative. The reality on the ground shows that lesson mathematics has still become eye difficult lesson understand Because nature is abstract, because contains numbers and formulas, Wahyuningtias (Rahmayani et al., 2021)

Geometry and measurement are some of the required materials studied by students. One of the material mandatory geometry studied by students is Prism. So that the goal of learning can be achieved optimally then demands object Prisma material requires sufficient reasoning. Students must control draft or formula mathematics (Adawiyah et al., 2023). Completion problem in finding wide surface prisms and volumes Prisms vary greatly Because in the process of discovery the right solution need noticed form from prism the. Based on the results interview with student of

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SMP Negeri 2 Larantuka that students difficulty finish related problems with Prism. The students used to memorize the formula, temporary solution problem prism depending on the type of prism base provided so that Lots students still experience constraint will matter the. Learning Prisma material is not Enough only with memorize formulas and doing it for example because just (Amin & Harahap, 2023). Activity memorizes formula only will endure in memory period short students, which will be later If appear questions only later related day with material the make student easy forget will memorized concepts. This matter is in line with Deep Yan (Trisnawati, Putri, & Santoso, 2015) who analyzed error answer students, it is known that error-dominant students appear in the finish question about wide surface prism in error draft. To overcome the problem the so study aim for help student in find Alone draft or Prism formula (Dalimunthe et al., 2021).

Trajectory Study or *Learning Trajectory* is something designed to attend learning level student in a way natural, that is student Studies with The method alone and individually actively builds his knowledge in a way that keeps going continuously. Before developing a *learning trajectory,* created something *Hypothetical Learning Trajectory* (HLT) and gained *Local Instruction Theory* (LIT). HLT is a hypothesis or prediction of how thinking or understanding students develop in activity learning, while LIT is the product end of the HLT that has been designed, implemented, and analyzed results of the learning. So the *Learning Trajectory* made as appropriate teaching materials used after several stages of experiment and adjusted with conditions student (Prahmana, 2017)

Gravemeijer (Prahmana, 2017) stated that HLT consists of 3 components namely (1) goal learning mathematics for students, (2) activities learning and the devices /media used in the learning process, and (3) conjecture or conjecture. To anticipate every response students who show up during activity study teach. The conjecture can be revised and developed Back to activity learning next based on the results of retrospective analysis after the teaching experiment was carried out (Towe, 2021) . HLT contains necessary steps passed by teachers and students in learning, possibilities to answer students who will appear in learning along support that will given by the teacher to students. For support, This Learning Trajectory needed some approach to learning To reach the objective desired learning (Eva Ervia et al., 2024).

According to Tan (Putri, Suryani, & Jufri, 2019) Problem-Based Learning (PBL) is innovation in learning Because in PBL ability to think student true, true optimized through the work process group or systematic team, so students can empower, hone, test, and develop ability he thought in a way sustainable. Lambors (Sudia et al., 2017) state that a learning-based problem

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is a learning model based on principles that use the problem as a first step For obtaining new knowledge. By using PBL, students can discover and build Alone draft the mathematics they studied (Harahap, 2018).

According to Ibrahim in (Wahyuningsih, 2019) put forward that PBL syntax is (1) Orientation students towards the problem: the teacher explains the learning objectives and the facilities or logistics needed, the teacher motivates students to be involved in selected real problem-solving activities, (2) Organizing students to problem: the teacher helps students define and organize learning tasks related to problems that have been oriented in the previous stage, (3) Guiding individual and group investigations: the teacher encourages students to collect appropriate information and carry out experiments to obtain the clarity needed to solve the problem, (4) Developing and presenting work results: teacher helps students in planning and preparing appropriate work as a result of problem-solving in the form of reports, models and sharing the task with friends (5) Analyzing and evaluating the problem-solving process: the teacher helps students to evaluate the problem-solving process carried out (Harahap, 2016).

Characteristics of Problem-Based Learning are as follows (Saputra, 2019) (a) Avoid learning isolated and teacher-centered; (b) Create learning interdisciplinary, student-centered over a period long time; (c) Integrated with the real world and experience; (d) Teach to student For capable apply what they learn in school life; (e) Learning Learning ; (f) Learning occurs in groups small; (g) Teachers play a role as a tutor and guide ; (h) Problem formulated For focuses and stimulates learning; (i) Problem is vehicle For development Skills solution problem; (j) Information new obtained past Study independent.

RESEARCH METHODS

Types of research this is a study design that is development-focused research theory and activity learning. Study This aims to design a trajectory study of the material-wide surface and volume of the prism using PBL and its application in learning using PBL. The study was implemented at SMP Negeri 2 Larantuka in 2023 for students class VIII b, totaling 12 students, and students class VIII a totaling 16 students. Study This is done in accordance with the stages stated (Akker et al., 2013) that is stage preparation (preparing for the experiment), stage study (design experiment), and stage analysis retrospective (retrospective analysis).

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At stage preparation or design introduction, HLT and device learning are designed. For designing HLT, the researcher does study literature, observations, and notes field. This Stage is done to observe the response of students to learning that has been designed. At stage this, the data is analyzed as input For revising and developing HLT in phases next is the stage study *(design experiment)*. HLT already revised will applied at stage study. Data collection techniques used is documentation, worksheets, interviews, and notes field. Data obtained in the research will analyzed in stages analysis retrospective *(retrospective analysis)*. Analysis process is done with compare hypothesis trajectory Study with the learning process that takes place within class. The purpose of analysis retrospective in a way general is to develop *local instructional theory* (LIT). Next, based on the results analysis of drawn data conclusion on research that has been done (Indrasvari et al., 2021).

RESULTS AND DISCUSSION

Several study previous related trajectory studies were carried out by (Rahmayani et al., 2021) with title, Track Design Learn Cubes and Blocks with Approach to Mathematics Education Realistic Indonesia in Class V Elementary School. Research results show that design trajectory Study cabbage and beam with an approach to mathematics education realistically, Indonesia is capable of facilitating understanding draft cubes and blocks student fifth-grade school base. The same thing was conducted by (Simamora, 2021) with title study Development trajectory Study Tree Discussion Triangle with Mathematics Education Approach Realistic Class VII at MTs Negeri 1 Padangsimpuan. Trajectory learning resulting from research This form of activity is carried out by students To reach objective learning, where objective learning is For understand understanding triangles, inequality triangles, types triangles, properties triangles as well as circumference and area triangles (Latif et al., 2020; Romansyah et al., 2019; Safitri, 2017a, 2017b; Safitri & Hasibuan, 2018).

More Studies conducted by (Hanifah & Sukirwan, 2023) with title, Learning Design Build a Flat Side Space Through *Problem-Based Learning* Helpful Geogebra. Analysis results review show that use context cake in learning get up room side flat through *problem based learning* find solution problems and help student linkages between context life real like cake with material get up room side flat as well as makes it easier student in understand material help geogebra. Therefore, researcher designing a trajectory Study with use of *problem-based learning* (PBL) on the material's wide prism surface and volume. For design trajectory study, the researcher referring to

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Gravemeijer & Cobb (2006), namely stage preparation *(preparing for the experiment*, stage study (design experiment), and stages analysis retrospective *(retrospective analysis)*.

At stage preparation, researcher do study literature that is form collection information about material learning material get up space and purpose learning For customized with the PBL model. Researchers also started designing a series activity necessary learning passed by teachers and students along with conjecture answer students who appear during the learning process . Conjecture channel Study student This nature dynamic which means can changed and adapted with circumstances student during the experiment process teach. Trajectory designed learning includes:

a. Designed learning objectives is student can find formula wide surface prism and prism volume.
b. Activity learning and conjecture answer student
   1) Stage Orientation
      a) The teacher conveys objective learning.
      b) Student requested observe get-up flat prism. The student requested determine side , edge, and point corners along with their respective amounts.
      c) Student moreover formerly requested For forming group discussion . Each group totaling 4 people.
      d) Next the teacher gives a problem to the student. The problem given loaded in activity following This:

Table 1. Hypothesis Trajectory Learning (HLT)

Activity Learning		Conjecture Answer Student
Activity 1	Find nets prism from piece get up flat square , square long and triangle	a. Student understand understanding from nets so that student with easy find nets prism based on piece get up given flat . b. Student understand understanding nets However student difficulty find nets prism based on piece get up given flat . c. Student No understand understanding from nets so that student difficulty find nets prism based on piece get up given flat .
Activity 2	Make get up prism from the nets formed	Student capable make get up prism based on nets the prism formed
Activity 3	Find formula wide surface prism	a. Student understand understanding wide surface and capable find formula wide

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		surface prism . b. Student understand understanding from wide surface However student difficulty find formula wide surface prism . c. Student No understand understanding wide surface and students difficulty find formula wide surface prism
Activity 4	Find prism volume formula	a. Student understand understanding of volume and students capable find prism volume formula . b. Student understand the meaning of volume however student difficulty find prism volume formula . c. Student No understand understanding volume and students difficulty find prism volume formula .

2) Stage organization

   At stage here , students requested For read questions and ask questions If There is things that haven't understood . Then student requested For finish given problem .

3) Level guide research individuals and groups

   At stage In this case , the teacher plays a role asshare facilitator where When students experience difficulty in finish problem , the teacher helps student with give strut form question guide For student find solution from problem the .

4) Stage develop and present results work

   The teacher asked representative from every group For present results solution ahead class .

5) Stage analyze and evaluate

   The teacher together with the student concludes the results of learning.

Activity study carried out at SMP Negeri 2 Larantuka with two cycles study. Activity Cycle I was carried out on 12 students in class VIII b and Cycle II was carried out on students in class VIII a. Activity cycle I was carried out For try-it-out design learning that has been done designed to develop and improve things still hinder the learning process. The results of cycle I will be applied For cycle II. After applying cycle I, research next to cycle II. When learning, students moreover formerly shared into 3 groups, with each group totaling 4 people. During the learning process, students were faced with 4 activities namely (1) find nets prism from piece get up flat

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square, square length and triangle, (2) make get up prism from the nets that are formed, (3) find formula wide surface prism, (4) Finding prism volume formula (Pratiwi & Harahap, 2022).

In activity 1, students requested to find nets prism triangle and facet four. For the prism triangle, students were given 2 wakes flat triangles and 3 shapes flat rectangles long, temporary For prism facet four, students were given 2 wakes flat squares and 4 figures flat rectangle. The working result student as follows:

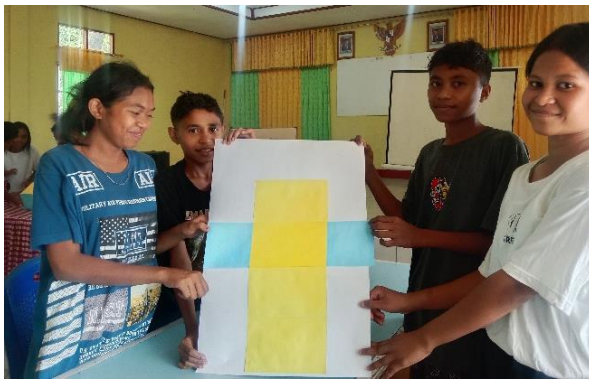

Figure 1. Quadrilateral Prism Nets

Figure 2. Triangular Prism Nets

In finishing the problem, students understood understanding from nets and most students were capable find the net prism, part students other still difficulty find net prism so the researcher helped with a strut to student For observe get up prism before (Sipayung et al., 2020), The researcher directed students to get up flat that forms prism and so on researcher direct student For try to compile pieces get up flat square, square long and triangular so that formed nets prism. In activity 4, all students were capable make get up a prism from the nets prism previously. The working result student can seen in the picture following:

Figure 3. Rectangular Prism

Figure 4. Triangular Prism

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In activity 5, all students experienced difficulty in finding the formula wide surface prism so the researcher gave a strut to the student that is student requested to observe get up the prism he made, then the student requested to find get up flat What only what is on the surface prism and so on student requested to find ideas for find formula wide surface prism. After being given strut these, students can find formula wide surface prism.

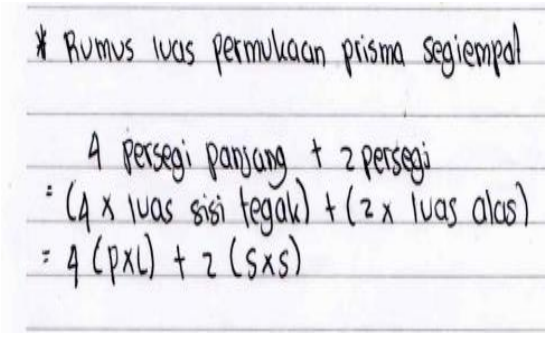

Figure 5. Surface area of a rectangular prism

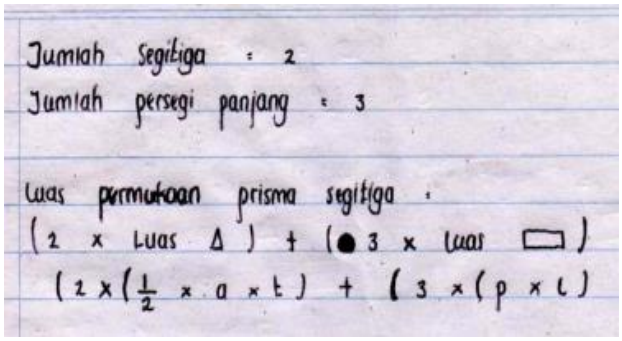

Figure 6. Surface area of a triangular prism

In Figure 5, students find that getting up flat on the surface prism facet four consists from 4 $persegi\ panjang + 2\ persegi$. To find the formula wide prism facet four, students Then count wide from get up flat. The student explained that 4 squares long is the side upright and 2 squares are side of the base, so the student wrote $(4 \times luas\ sisi\ tegak) + (2 \times luas\ alas)$. Student Then finds formula wide surface facet four that is $4(p \times l) + 2(s \times s)$. $p$is a representation of length, $l$is a representation of width, and $s$is a representation of sides.

In Figure 6 above, students moreover formerly wrote amount get up flat on the surface prism Δ facet three. Student writes amount facet three = 2 and sum rectangle length = 3. Because of the facet three on the surface prism total 2 and rectangles total 3 , then student write wide surface prism = (2 x Luas Δ) + (3 x Luas ▭) The shape and ▭ is a representation of triangles and (2 x (1/2 x a x t) + (3 x (p x l) quadrangles. The next step is for students to describe the area of the triangle, namely $\frac{1}{2} \times a \times t$and the area of the rectangle, to be $(p \times l)$. $a$is a representation of the base of the triangle, $t$is the height of the triangle, $p$is the length and $l$is the width. Students write the formula for the surface area of a prism, namely

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In activity 6, students had difficulty finding the prism volume formula so the researcher gave strut to the students namely volume is filled rather than a get-up room. Student was directed to recalling concepts of the volume of the cube and then requested to apply a draft on the prism while paying attention to the base of each prism. After giving strut that, in part, the big student then found the prism volume formula triangle, whereas the student other not appropriate find the prism volume formula. Student Write down the volume of the prism facet four namely (length x width) x height, while the base is formed on the prism facet four is a rectangle. So the role of the teacher is to support students For understanding that prism facet four has a shaped base rectangle. The working results in students are as follows:

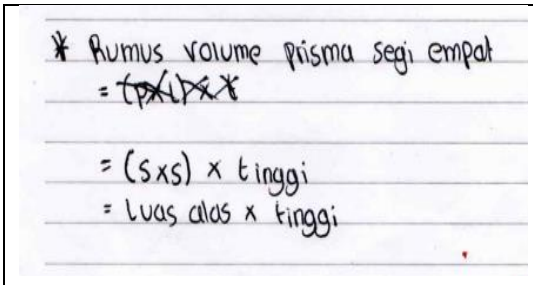

Figure 7. Volume of a rectangular prism

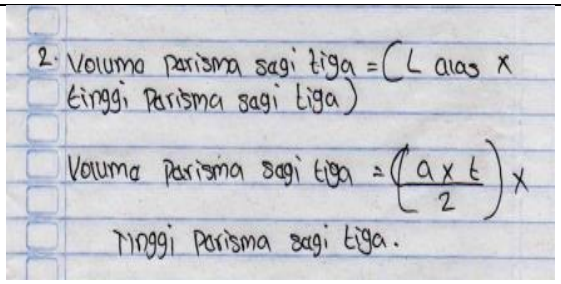

Figure 8. Volume of a Triangular Prism

In Figure 7, students write the prism volume formula facet four = $(p \times l) \times t$. By looking at the student's writing, the teacher provides support. The teacher asks the students To observe the base form of prism facet four. After knowing it was a mistake, the student then repaired with writing the formula wide surface prism facet four = $(s \times s) \times tinggi$. Because the base of a rectangular prism is square, students conclude that the volume of the prism is the area of the square multiplied by the height of the prism. In Figure 8, students write the volume of a triangular prism = $(L.alas \times tinggi\ prisma\ segi\ tiga)$. The letter L represents the area of the base. Because of the prism base-shaped triangle student deduce the volume of the prism = $\left(\frac{a \times t}{2}\right) \times tinggi\ prisma\ segitiga$.

After carrying out the learning process, stages furthermore researcher does an analysis retrospectively. Analysis retrospective according to Gravemeijer & Cobb (Trisnawati et al., 2015) state that at that stage Here (Winangsih & Harahap, 2023), HLT is compared with learning real students so that the result is used For answer formulation problems. At stage analysis retrospective, the researcher does analysis with compares design learning in HLT with a learning process carried out in stages study. Based on the activity learning carried out is known that student Already capable understand , analyze and discover a number of matters in learning. In

activities 1 and 2, students find that nets is get up flat forms get up room prism. In activity 3, students analyze and discover that a wide surface prism is wide from all over the surface get up a prism, and the formula wide prism is an amount from wide all get up flat on the surface prism. In activity 4, students analyze and discover that volume is filled on wake-up space, and well prism volume formula is base area x height.

CONCLUSION

Based on the results and Discussion study so can concluded that the design trajectory Study For the material wide surface and volume of the prism with the PBL model is theoretically capable of facilitating the invention draft wide surface and volume of the prism student class VIII of junior high school. The learning process has also been load PBL steps viz orientation, organization, guiding investigation individuals and groups, developing and presenting results works , analysis and evaluates.

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