Development of Learning Design to Polyhedron Based Approaches Realistic Mathematics Education to Improve Ability Mathematical Reasoning for Class VIII Junior High School (Preliminary Research)

Ceci Raflis, Edwin Musdi

Abstract—The flow of mathematics teaching on the topic of polyhedron so far still uses alor improvised display provided by the schooll and emphasize memorization formula and providing training for teacher-centered students. Learning design is needed that can facilitate students to actively participate in building the concept of polyhedron Class VIII Junior High School based on RME with a learning trajectory in the form of HLT and product implementation of teacher books and student books. This type of research is a combination of the two type of design research is that's design Plomp and Gravemeijer models and Cobb which consists of three phases, that's preliminary research, development or prototyping phase, and assessment phase. This article discusses the preliminary section. Teacher interview guidelines, student interview guidelines, field notes, preliminary test questions for students' reasoning abilities are used as instruments. From this preliminary research phase, it can be concluded as follows: 1) teachers are guided by printed books owned by teachers and students, which have not facilitated students to develop concepts through meaningful learning activities, 2) teachers also has not designed an appropriate learning flow to teach a mathematical topic 3) students' reasoning abilities are not optimal, 4). the preparation of the learning flow will be in accordance with the results of curriculum analysis.

Index Terms— Build Flat Side Space, Social arithmetic, RME, Learning Design.

————————————— ◆ —————————————

1 INTRODUCTION

Mathematics is one of the subjects taught at all levels of education which has an important role in the development of mathematical abilities of students. The results of mathematics education are that students are expected to have creative, critical, scientific thinking, honest, frugal, disciplined, diligent, humane, have a sense of justice, and are responsible for the welfare of the nation and state [1]. Mathematics is a universal science that has a very important role in various scientific disciplines and advancing the power of human thought [2] According to Albert Einstein, mathematics actually offers natural knowledge a certain measurement, which without mathematics all of which would be impossible to obtain [3].

One of the materials in mathematics, especially about geometry, is material to polyhedron. Polyhedra into one of the materials learned in class VIII semester 2 and contained in curriculum K13 Mathematics in junior high school which has an important role, because polyhedron is a mathematical material that we often encounter in our daily lives. Society without them knowing is often around objects in the form of flat side spaces, for example, they live in houses in the form of

polyhedron. The teacher must be able to organize a polyhedron program that allows for individual student progress in learning mathematics. Therefore, it is important to teach the material to polyhedron to equip them in solving real problems and also to help the development of their mathematics learning.

The flow of mathematics teaching on the topic of polyhedron so far is still using alor improvised display provided by the schooll and emphasize memorization formula and providing training for teacher-centered students. Teaching like this has an impact on the ability of students who are unable to build their own knowledge but tend to memorize the concepts of polyhedron without knowing the meaning contained in the concept. The students have difficulty in working on the problem given if it is not preceded by giving a formula. Even though the material to polyhedron is material that discusses about real life, which is about the place of residence, tools that they often encounter everyday, such as cupboards, cake boxes, shoe boxes, cardboard boxes, roofs of buildings and much more.

This condition was also found when conducting preliminary studies in several schools, especially students of class VIII SMP in Kerinci Regency, that is SMPN 37 Kerinci and SMPN 21 Kerinci on September 2 - 9, 2019. Based on observations and interviews with several mathematics teachers, information was obtained that The teacher is guided by the printed books owned by the teacher and students in the topic of learning to polyhedron with the learning flow in the handbook less contributing to the development of student learning, especially in

————————————————

- *Ceci Raflis is graduate students from Universitas Negeri Padang, Indonesia, E-mail: ceciraflis@gmail.com*
- *Edwin Musdi is lecturer mathematics educations, Universitas Negeri Padang, Indonesia, E-mail: win_musdi@yahoo.co.id*

the development of ability mathematical reasoning. Whereas available textbooks generally tend to encourage teachers to teach mathematics mechanically and algorithmically [3]. The description of teaching materials used by teachers can be seen in Figure 1.
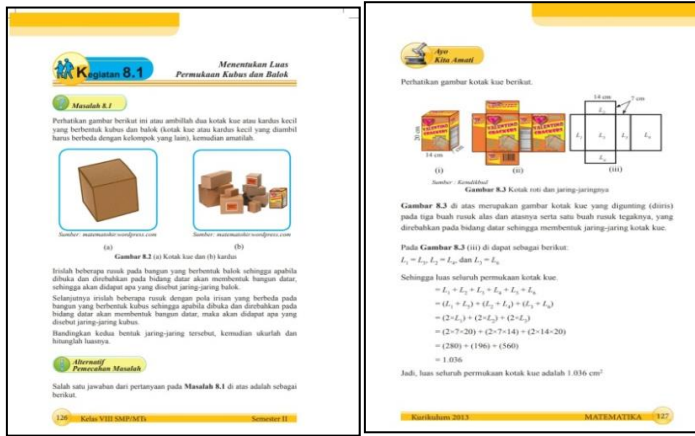

Figure 1. Example of Presentation of Material in Polyhedra in Mathematics Book for Class VIII Middle School

Based on these pictures, it appears that the book has presented a real problem in starting learning. It's just that the material is presented directly with formulas and examples of problems by providing alternative answers. The book guided by the teacher has not facilitated students to develop concepts through meaningful learning activities. This causes learning to still be centered on the teacher. Students only accept the conclusions and formulas given by the teacher and memorize them without understanding their meaning. Though many things take precedence over memorizing formulas so that learning becomes quality like connecting mathematics with everyday life and being updated to date, of course, using a reasoning approach, and emphasizes the relationship between ideas [4]. Students also cannot solve problems without the formula given. With the existing formula students enter numbers according to the formula without understand the meaning.

Some research results on mathematics learning also show that there are still problems with learning to polyhedron. Learning about building space in Indonesia focuses learning on procedural calculations with learning activities that are mechanistic. Students have not been given the opportunity to discover, understand and experience the learning process themselves. This results in students not understanding the concept of volume and surface area and the interrelationships of the two concepts [5]. Rostika found that students experienced boredom because learning was not interesting [6]. The teacher does not provide opportunities for students to actively manipulate objects directly, so that most students find it difficult to understand every concept taught. according to French, students are still confused in understanding the surface area of building space because students find it difficult to visualize three-dimensional fields and present them in two dimensions [7]. Students learn the procedure step by step with the teacher showing how to solve problems. this causes knowledge to be inflexible and not problem based [8]. The teacher tends to ask students to remember rather than stimulate them to construct knowledge [9]. this also happened at SMPN 37 Kerinci.

The fact that occurs in the field also shows that the ability of the reasioning level is not optimal. Thingllthis seendfrom the initial test results of the pen's ability. The meeting was attended by 25 students of class VIII of SMPN 37 Kerinci. Dith the initial ability test questions as follows:

1. *Andi will make regular rectangular pyramid with 10 cm long rib base. What is the area of the carton needed to make the pyramid?*
2. *Mr. Revi went to the glass shop to membei glass as a material for making aquariums that are ba-shapedlok with a size of 100 cm x 30 cm x 50 cm the price of 1m2 glass is Rp.50,000, - Mr. Rahmat handed over Rp.100,000 to the sellerl and expects a return of Rp.52,500 while selling l only developing as much as Rp. 5,000 proves whose opinion is correct?*

From the results of the students' initial ability tests it was found that there are still many students who do not yet have good reasoning skills. Most students have difficulty in solving questions in the form of reasoning, especially on indicators compiling a settlement plan and checking again. From the calculation results obtained an ideal score of 12 and an average score of students of 5.1 or 42.5% of the ideal score. in this case it appears that the reasoning score of students is still below 50% of the ideal score. Even though the problem has stated what strategies will be used to solve the problem. But students tend to process the numbers by guessing the solution instead of compiling how the steps must be taken to get a solution.

The problem of reasoning in learning geometry can be overcome if innovations are made in the learning process. The learning process should be able to facilitate students to explore learning activities related to the ability of reasoning so that students can understand the concept of surface area and volume well. The cognitive development of the average student at the junior high school level is in the transition stage from the concrete thinking stage to the abstract thing.

Based on the phenomena that have been described, the authors argue that learning designs are needed to overcome these problems. This learning design was developed using Realistic Mathematics Education (RME). RME starts from 'real' things for students, emphasizing skills 'process of doing mathematics', discussing and collaborating, arguing with classmates to be able to discover for themselves and use mathematics to solve problems both individually and in groups. Through discussion activities in the classroom, learning becomes more effective [5]. In using the RME approach, students will be guided in discovering mathematical concepts through the process of horizontal and vertical mathematization.

Research [2] is also motivated by the low reasoning ability of students. The results of the study stated that RME was effective against students' reasoning abilities. In line with the results of the study [10] concluded learning with PMR can improve students' mathematical reasoning ability. Research on RME has been widely carried out such as [11] and [12] both studies concluded that RME is suitable to be applied in the process of learning mathematics to learn a material and in improving students' reasoning abilities.

2 METHOD

The purpose of this research is to develop the learning trajectory of RME-based polyhedron building topics, so that the research is categorized as design research. This research activity was carried out by combining two types of research design that's the Plomp model design [13] and Gravemeijer and Cobb [14]. The combination of these two types of design research aims to produce valid, practical and efficient LIT, teacher books and student books.

By combining these two models it will be mutually reinforcing and at some stage it is suitable to be merged. The learning design model of Gravemeijer & Cobb, has the privilege of developing the learning flow, the product produced in the form of local instructional theory, and for its implementation it is needed a product in the form of teaching material (teacher's book and student book) who need validity, practicality and effectiveness, which was developed using the plomp model. This design research has three phases, i.e. preliminary research, stages prototype (development or prototyping phase), stage assessment (assessment phase).

3   RESULTS AND DISCUSSION

The preliminary research phase is carried out to obtain information about the problems that exist in the world of education. In addition, this phase is carried out to obtain an overview of the learning flow developed. At this stage the identification or analysis needed to develop the learning design of the topic of RME-based polyhedron and analyze the boundaries of the subject matter to be developed. The purpose of this stage is to establish and define the requirements needed in the development of learning designs. Activities carried out in the preliminary research phase, that is:

3.1 Needs Analysis Results

Based on the results of interviews conducted with 37 Kerinci Junior High School teachers regarding the obstacles encountered by educators in learning about the topic of polyhedron this time. The teacher explains that he has not yet applied the learning flow in the topic of polyhedron that can help students find concepts, the teacher only submits material according to the existing lesson plans, by utilizing library books. The teacher gives an illustration that students generally memorize the formula without understanding its meaning. Educator will only do the exercises if the teacher member on the cue of the assignment is gathered. Students copy the assignments of friends who are classified as smart with the reason the questions in the textbook are too difficult. Existing textbooks are inadequate to facilitate the mathematical abilities of learners in learning.

Based on the results of interviews with 37 Kerinci SMPN teachers, the teacher also has not designed an appropriate learning flow to teach a mathematical topic because of the limited ability and time to create a learning flow that is in accordance with the characteristics of the student participants. Polyhedron has been taught according to what is in the handbook. For example, explaining about cubes and blocks with media only provided by schools, giving examples of questions then asking students to do exercises. The media used is actually the teacher can

add to the example of concrete objects that are around and are popular at that time. so students can understand the subject matter well. As a result of the learning process that is not yet optimal, when students are given questions that are different from the sample questions, the average student participant has difficulty to solve them.

In general, teachers are still guided by textbooks provided by schools and handbooks purchased outside. Presentation of the handbook especially the material on the construction of flat side spaces has presented a real problem, it's just that the material is presented directly by giving a definition and proceeding with the formula to determine it. From the test results of the reasoning ability of the participants it was also found that the reasoning ability of the participants was not optimal.

The results of the analysis that have been carried out show that the educators need a learning design that can facilitate the active participation of students in developing the concept of building a flat side space. One effort to overcome the problems in the learning process is to develop an RME-based learning flow that is designed in such a way as to overcome these problems.

3.2 Curriculum Analysis Results

The activity carried out at this stage was an analysis of the material in the curriculum used, that's the 2013 revised 2016. Curriculum. This activity is carried out to study the scope of the material, the learning objectives, and to find out whether the material on flat side buildings in the curriculum is in accordance with the expected competencies, whether the material is sufficient to achieve the learning objectives, and whether the material is well ordered. The activities carried out in this analysis are analyzing KD and indicators of student competency achievement for the topic of polyhedron.

The results of this curriculum analysis are used to formulate indicators learning achievement which is a guideline in developing the learning trajectory of RME-based polyhedron topics Class VIII junior high shcool. The results of curriculum analysis that have been formulated can be seen in Table 1.

TABLE 1
THE DESIGN OF HLT

BC Before Analysis	Indicators of achievement of competence after analysis
5.1 Identifying the properties of cubes, beams, prisms and pyramid.	5.1.1 Identifying properties, making nets and calculating cube surface area.
	5.1.2 Identifying properties, making nets and calculating beam surface area.
	5.1.3 Identifying properties, making nets and calculating the surface area of a prism.
5.2 Making cube nets, beams, prisms and pyramid.	5.1.4 Identifying properties, making nets and calculating the surface area of the pyramid.
5.3 Calculate surface area and volume of cubes, beams, prisms and pyramid.	5.1.5 Calculate the volume of a cube.
	5.1.6 Calculate beam volume.
	5.1.7 Calculate prism volume.
	5.1.8 Calculate the volume of the pyramid.

In tors developed by the teacher is first to identify the elements of 3D shapes, nets of 3D shapes, surface area and volume. Indicators of the analysis results are presented for one whole building, for example, in the first material students discuss elements, nets and surface area of a cube.

Researchers make changes and incorporate indicators so that students form their full knowledge about each 3D shape and so that there is no repetition or separation of material in learning.

3.3 Concept Analysis Results

The activity carried out at this stage is an analysis of essential materials that will be discussed in the topic of learning to polyhedron in class VIII of junior high school. This activity is carried out to select and establish, detail and arrange systematically relevant teaching material to be taught based on curriculum analysis. The activity carried out in this analysis is to identify essential materials in the topic of polyhedron of class VIII of junior high school, then to arrange them systematically by linking one concept to another concept that is appropriate so as to form one concept and organize the material to determine the order of the material at each meeting.

For the order of material according to curriculum analysis, it starts with finding the concepts of cubes, beams, prisms and pyramid. The concept map for the topic of polyhedron can be seen in Figure 2.
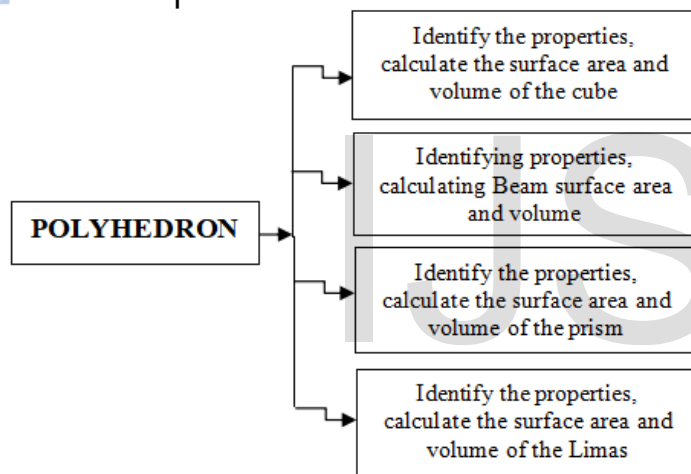

Figure 2. Concept Map Topic Polyhedron

Based on the picture, it can be seen that the material in building a flat side space contains cubes, beams, prisms and pyramid. associated with problems in daily life, the essential concept on the topic of polyhedron that should be the surface area and the volume of the 3D shapes. In this research in finding the concept of surface area of the polyhedron will understand the nets and identify the properties of the geometric shape.

3.4 Student Analysis Results

The activities carried out at this stage are an analysis of the characteristics of the students in class VIII of junior high school and what kind of learning the students want. The activities carried out in this analysis are observation and interviews. The focus of this analyzing activity lies in the characteristics of individual students which include, among others: cognitive levels, age, learning styles, motivation towards mathematics lessons, students' views of the methods used by teachers in teaching, and the colors that are preferred by students.

The results of the analysis of the characteristics of learners obtained some information which is used as a basis for designing learning designs based on RME. Information about students' academic abilities is obtained by providing preliminary tests that are tailored to reasoning ability indicators. From the results of these tests, it appears that students' reasoning abilities are not optimal. Students like to group, students like to learn with the context of problems related to the present (update) and in accordance with their ages ranging from 13-14 years, and dominant students like the blue book. With these things will bring up the interests, inspiration, motivation and activities of students.

Teachers still teach conventionally because they do not have a guide book that guides the course of learning with student centers. If learning with a student center later on when learning the teacher is only as a facilitator and students who find their own concepts. So as to facilitate students actively participating in building the concept of polyhedron. Therefore it is very necessary student books and teacher books designed with the RME approach. The material for constructing flat side spaces is suitable to be presented with contextual problems such as those already existed in the text books that are used only when an RME-based learning trajectory is needed that is designed in such a way as to develop students' concepts. Students need a product that is a student book that is able to support learning that gives freedom to students in giving opinions and finding concepts by themselves so that learning becomes meaningful and will be able to be remembered for a long time. Likewise with the teacher, it should use a teacher's book that is able to be a guide in teaching in the classroom so that learning is more directed and matched with the student book given.

3.5 Review Literature

The activity carried out at this stage is the analysis of theories and concepts relating to the development of the topic of flat side spaces. This activity is carried out as a guide and consideration in designing the learning trajectory of the RME-based polyhedron topic. The activities carried out in this analysis are reviewing research journals on learning trajectories and guidebooks that study about polyhedron.

Riview literature aims to examine what was done by previous researchers related to the process of designing learning in particular topics polyhedron. Besides that, we also read literature about the Realistic Mathematics Education (RME) approach, as well as the literature on students' mathematical reasoning abilities. From the literature read, a new inspiration was obtained to design the learning trajectory of polyhedron topics using the RME approach. Literature that is read in developing the learning flow of the topic of polyhedron includes journals made by Van Hiele, Karshaw, Wahyuni and so on.

The geometry learning utilities are suggested [8], placing identifying shapes and numbers according to concrete examples. At the second level, students identify shapes according to their characteristics (for example that a rhombus is built with the same four sides). At the third ('abstract') level, students can identify the relationship between building (for example, a square is a special shape of a rectangle) and can find traits

with simple physical education. At the fourth ('formal') level, students can produce concise reports concisely and make conclusions. In this study, students were also given a concrete object to find the surface area of the building. In finding surface area, students will construct their knowledge about the properties of 3D shapes.

On the topic of 3D shapes, the reader reads some of the literature, including in research [10] which produces learning trajectories in learning the volume of cubes and beams involving the visualization ability of the class VIII. The model used in the learning of the volume of 3D shapes is a rubik of the same size. Whereas in this study using the unit cube as a learning model.

Determining the surface area can be done by using nets and of course using concrete objects that aim to make students able to present two-dimensional shapes from the spatial plane [11]. In this study, for the initial stage students also used the nets to find the cardboard area needed to make a box and for the next students would calculate the area of material used to make a building.

Many other literatures are used to design the learning trajectory of this topic on polyhedron, including for comprehension test questions which also help students in constructing concepts in the topic of polyhedron. As for the topic of 3D shapes volume, the researcher uses the learning trajectory used in the 2013 curriculum student manual, which uses the context of the unit cube to facilitate students to find the volume of 3D shape. After the concept of 3D shape volume is discovered by students, students will develop their knowledge into other 3D shape volume like pyramid by arranging the pyramid in a cube. From this activity students discover the relationship between pyramid volume and cube volume.

Based on the review of the literature on the topic of learning to polyhedron, overall the concept of polyhedron must be presented to students through the real-world problem that can stimulate students in constructing their own polyhedron concepts. therefore, it is necessary to design a topic learning design to polyhedron using the RME approach.

4 CONCLUSION

From this preliminary research phase, it can be concluded as follows: 1) teachers are guided by printed books owned by teachers and students, which have not facilitated students to develop concepts through meaningful learning activities, 2) guru also has not designed an appropriate learning flow to teach a mathematical topic 3) students' reasoning abilities are not optimal, 4). the preparation of the learning trajectory will be in accordance with the results of curriculum analysis.

Based on needs analysis, curriculum analysis, concept analysis, student characteristics analysis and literature review, learning designs are needed that can facilitate students to actively participate in building the concept of RME-based polyhedron topics class VIII junior high school to improve students' mathematical reasoning abilities with a learning trajectory in the form of HLT and the product implementation of teacher's books and student books.

REFERENCES

[1] Ruseffendi, E.T. 1991. Pengantar Kepada Membantu Guru Mengembangkan Kompetensinya dan Pengajaran Matematika untuk Meningkatkan CBSA. Bandung: Tarsito.

[2] Badan Standar Nasional Pendidikan (BSNP). (2006). Lampiran Peraturan Menteri Pendidikan Nasional No 22 Tahun 2006 Tanggal 23 Mei 2006. Jakarta.

[3] Wahyudin, 2008. Kurikulum, Pembelajaran, dan Ealuasi. Bandung: Ipa Abong

[4] Eriksson, K., Helenius, O., & Ryve, A. 2019. "Using TIMSS Items to Evaluate the Effectiveness of Different Instructional Practices". Instructional Science, 47(1), 1-

[5] Fauzan A, Plomp T and Gravemeijer K. 2013. Educational Design Research Part B: an Introduction ed T Plomp and N Nieveen (Enschede, SLO) p 159-178.

[6] Deswita, Hera. 2013. Pengembangan Perangkat pembelajaran Berbasis Masalah untuk Kelas VII Sekolah Menengah Pertama. Tesis tidak diterbitkan. Padang: UNP

[7] Rusman. 2010. Model-Model Pembelajaran: Mengembangkan Profesionalisme Guru. Jakarta: Rajawali Pers

[8] French, M.G. dan Roland, L. 2004. Writing, Reading, and Assessing in an Elementary Problem Solving Class. In Problems, Resources, and Issues in Mathematics Undergraduate Studies: ProQuest Educatio Journals

[9] Hauve, Van De, Panhuizen, M., & Drijvers, P. (2014). Realistis Pendidikan Matematika. Dalam S. Lerman (Ed), Ensiklopedia Pendidikan Matematika(pp.521-525). Dordrecht, Heidel berg, New York, London : Springer Diakses pada tanggal 26 April 2019 di http:/www.staff.science.uu.nl/-heuvel108/download-rme/VdHauvel-Drijvers_2014_ENCYCLOPEDIA_RME-ref.pdf

[10] Susanto, S. I. 2013. "Peningkatan Kemampuan Komunikasi Matematika Dan Keaktifan Siswa Melalui Pendekatan Realistic Mathematics Education (RME) Pokok Bahasan Segi Empat (PTK Pada Siswa Kelas VII SMP Negeri 3 Delanggu". (Doctoral Dissertation, Universitas Muhammadiyah Surakarta).

[11] Wahyuni, Reni. 2015. Volume Kubus dan Balok Melibatkan kemampuan Visualisasi Spesial di Kelas VIII . Jurnal Elemen Vol. 1 No. 2, Juli 2015, hal 41-51.

[12] Kershaw, Jen.2013. Surface Area of triangular prisma. Kansas: Flexbook.

[13] Plomp, Tjeerd & Nieveen, Nienke. 2013. Educational Design Research. Part A. An Introduction. SLO. Netherlands Institute for Curriculum Development.

[14] Gravemeijer, Koeno and Cobb, Paul. 2006. Design research from the Learning Design Perspective. Dalam Jan Ven Den Akker, et. al. Educational Design Research. London: Routledge.