The Development of Learning Design for Polyhedron Based On Realistic Mathematic Education for Grade VII of Junior High School Students

V Prestiani¹, Irwan¹ and I M Arnawa¹ ²
¹Department of Mathematics Education, Universitas Negeri Padang, Indonesia
²Department of Mathematics, Universitas Andalas Padang, Indonesia

Email: 23vindaprestiani@gmail.com

Abstract. The flow of teaching mathematics on the topic of Polyhedron all this time emphasizes memorization of formulas and the provision of exercises to students which are still teacher-centered. Learning design is needed to facilitate students to actively participate in building the concept of building a flat-sided classroom in grade VIII of Junior High School based on Realistic Mathematic Education using the learning flow in the form of Hypothetical Learning Trajectory and implementation products in the form of teacher books and student books. This type of research was development research that combines two types of research design, namely the Plomp and Gravemeijer and Cobb models which consist of three phases: preliminary research, development or prototyping and assessment phases. This research was limited to preliminary research. Teacher interview guidelines, student interview guidelines, field notes, preliminary test questions for students' mathematical reasoning abilities are used as instruments. From this preliminary research phase, it could 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 had not designed learning paths which was appropriate for teaching a mathematical topic, (3) the mathematical reasoning ability of students was not optimal, (4) the preparation of the learning flow was in accordance with the results of curriculum analysis.

1. Introduction

Many math topics are considered difficult by students, so that they have an impact on the low math ability of students [1-8]. Polyhedron is one of the mathematics topic in junior high school that has an important role, because Polyhedron is a mathematical material that we often encounter in our daily lives [9],[10]. People apply in the field of building and wrapping a box. The teacher must be able to organize a Polyhedron program that allows for individual student progress in learning mathematics. Therefore, teaching material to build a Polyhedron is important to be given to students to equip them in solving real problems and also to help the development of learning mathematics.

The flow of teaching mathematics on the topic of Polyhedron all this time emphasizes memorization of formulas and the provision of exercises to teacher-centered students. Teaching to build Polyhedron like this has an impact on the ability of students who are not able to build their own knowledge but tend to memorize
the concepts of Polyhedron without knowing the meaning contained in the concept. Learners have difficulty in working on the questions given if not preceded by giving a formula. Even though the material to build Polyhedron is material that discusses real life such as determining the area of paper to wrap gifts, the area of the wall to be painted which they will practice in their daily lives [11],[12].

This condition was also found when conducting a preliminary study at Junior High School number 11 Padang on 27 August - 2 September 2019. Based on the results of observations and interviews with mathematics teachers, information was obtained that the teacher was guided by printed books owned by teachers and students in learning the topic of Polyhedron with the learning flow in the handbook is less contributing to the development of student learning, especially in the development of students' mathematical reasoning abilities. Whereas available textbooks generally tend to encourage teachers to teach mathematics mechanically and algorithmically [13].

The fact also showed that the students' mathematical reasoning ability is not optimal. This can be seen from the results of preliminary tests of reasoning ability followed by 30 students of grade VIII B class at Junior High School number 11 Padang, that the mathematical reasoning of students is low in determining patterns / traits of mathematical symptoms to make generalizations and indicators of mathematical manipulation.

Based on the phenomena that have been described above, the researcher believes that learning designs are needed to overcome these problems. This learning design was developed using Realistic Mathematic Education (RME). RME is the 'real' things for students, emphasizes the 'process of doing mathematics' skills, discusses and collaborates, argues with classmates to be able to discover for themselves and use mathematics to solve problems both individually and in groups. Through discussions in the classroom, learning becomes more effective [14]. In line with the results of research [15],[16] concluded that learning with RME can improve students' mathematical reasoning. There have been many studies on the use of RME in improving mathematics learning outcomes [17],[18]. They concluded that RME is suitable to be applied in the process of learning mathematics to learn a material as well as in improving students' mathematical reasoning abilities.

2. Materials dan Methods
This study aimed to develop a flowchart of RME- Polyhedron topics, so the research was categorized as a research development using the Plomp model and Gravemeijer and Cobb [8],[13],[18]. The combination of these two types of design research aimed to have valid, practical and efficient LIT, teacher and student books.

The Gravemeijer & Cobb learning model design can describe the learning flow, the product produced in the form of local instructional theory, and for its implementation the product is needed in the form of teaching materials (teacher books and student books) that require validity, practicality, and effectiveness that are developed using the Plomp model [19-25]. This research design had three phases, namely preliminary research, prototype and assessment phase.

3. Results and Discussion
Preliminary research phases was applied to obtain information about problems in learning. In addition, this phase was to see the overview of the developed learning flow. At this stage, identification or analysis was needed to develop the design of learning the topic of RME-based flat side building and analyze the boundaries of the subject matter to be developed. The purpose of this stage was to establish and define the conditions needed in the development of learning designs. Activities in the preliminary research phase were (1) Requirement Analysis, (2) Curriculum Analysis, (3) Concept analysis, (4) Student analysis, (5) Literature review.
3.1. Results of needs analysis

Based on the results of interviews conducted with Junior High School number 11 Padang teachers about the obstacles encountered by educators in learning about the topic of Polyhedron. The teacher explained that he had not applied the learning flow in the topic of building Polyhedron that can help students find concepts, the teacher only submits material in accordance with the existing lesson plans, by using library books. The teacher gave an illustration that students generally memorize the formula without understanding its meaning. Educators would only do the exercises if the teacher gives the cue for the assignment to be gathered. Students copied the assignments of friends who are classified as smart with the reason the questions in the textbook are too difficult. Existing textbooks were inadequate to facilitate the mathematical abilities of learners in learning.

Based on the results of interviews with teachers of Junior High School number 11 Padang, the teacher also had not designed an appropriate learning flow to teach a mathematical topic because of the limited ability and time to make a learning flow that is in accordance with the characteristics of the teacher. Building a Polyhedron had been taught according to what is in the handbook. For example, explaining the formula for the surface area of the beam, giving examples of questions then asking students to do the exercises. When the participants were given questions that were different from the sample questions, the average participant found it difficult to solve.

In general, teachers were still guided by textbooks provided by schools. Presentation of the handbook especially the material on the construction of Polyhedron had presented a real problem, it's just that the material is presented directly by giving a definition and continued with the formula to determine it. From the results of the test of students' mathematical reasoning ability it was also found that the mathematical reasoning ability of the students was not optimal.

The results of the analysis that had been done showed that the educators need a learning design that can facilitate the active participation of students in developing the concept of Polyhedron. One effort to overcome the problems in the learning process was to develop an RME-based learning flow that is designed in such a way as to overcome these problems.

3.2. Results of Curriculum Analysis

The activity at this stage was an analysis of the material in the curriculum used, namely the 2013 revised 2016 Curriculum. This activity was to study the scope of the material, the learning objectives, and to find out whether the material about building a flat side space in the curriculum was in accordance with the expected competencies, whether the material was sufficient to achieve the learning objectives, and whether the material was well ordered. The activities were analyzing the Basic Competency and Indicators of student competency achievement for the topic of Polyhedron.

The results of this curriculum analysis were used to formulate indicators of learning achievement that serve as a guideline in developing the learning pathway of the topic Polyhedron in grade VIII of Junior High School. The results of curriculum analysis that have been formulated can be seen in Table 1.
Table 1. Results of curriculum analysis

| Basic competency | Indicator before analyzed | Indicator after analyzed |
|------------------|---------------------------|--------------------------|
| 1. Differentiate and determine the surface area and volume of Polyhedron (cubes, beams, prisms, and pyramid) | 1. Determine the surface area of cubes and cuboids | 1. Determine the surface area of a cube using visual aids in the form of real objects |
|                  | 2. Determine the volume of the cube            | 2. Determine the surface area of the cuboids using props in the form of real objects |
|                  | 3. Determine the surface area of the prism     | 3. Determine the surface area of the prism through the activity of coating chocolate with wrapping paper |
|                  | 4. Determine the volume of the prism           | 4. Determine the surface area of the pyramid by covering the pyramid-shaped box with wrapping paper |
|                  | 5. Determine the surface area of the pyramid   | 5. Determine the volume of cubes and cuboids by arranging unit cubes |
|                  | 6. Determine the volume of the pyramid         | 6. Determine the volume of the prism by inserting two prisms into a block-shaped box |
|                  | 7. Determine the volume of cubes and beams     | 7. Determine the volume of pyramid by arranging six pyramid into cubes |
| 2. Resolve problems related to surface area and volume of Polyhedron (cubes, beams, prime and pyramid), and their combinations | 8. Estimating irregular surface area and volume of space by applying basic geometry through the illustration shown. | 8. Estimating irregular surface area and volume of space by applying basic geometry through the illustration shown. |
|                  | 9. Calculate the irregular surface area and volume of the building by applying its basic geometry through the illustration shown | 9. Calculate the irregular surface area and volume of the building by applying its basic geometry through the illustration shown |
|                  | 10. Present the results of learning about Polyhedron | 10. Present the results of learning about Polyhedron |

Based on the analysis of basic competency and indicators, the sequence change was applied. This was to adjust the level of difficulty and the relationship between concepts to learning. Therefore, researchers slightly changed the order of the implementation of their lessons so that students easily understand the topic of Polyhedron.

3.3. Results of literature review

The activity was an analysis of the essential materials that will be discussed in the learning of the topic of class VIII middle school classrooms. This activity was to select and determine, 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 in grade VIII of junior high school, then to arrange them systematically by linking one concept to another concept that is suitable so as to form one concept and organize the material to determine the order of materials at each meeting. The subject matter on the topic of Polyhedron were 1) the surface area of the beam; 2) cube surface area; 3) the surface area of the prism; 4) pyramid surface area; 5) volume of strongholds and beams; 6) volume of prism and pyramid.

3.4 Results of student analysis

The activities were an analysis of the characteristics of the students in grade VIII of junior high school and what kind of learning the students want. They were observation and interviews. The focus of this analyzing activity was in the characteristics of individual students which include were cognitive levels, age, learning styles, motivation towards mathematics lessons, students' perception about the methods used by teachers in teaching, and the colors that were liked by students.
The results of the analysis of the characteristics of learners obtained some information which was used as a basis for designing learning designs based on RME. Information about students' academic abilities was obtained by providing initial tests that are adjusted to the indicators of mathematical reasoning ability. From the test results, it could be seen 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 old, and dominant students like the blue books. With these things will bring up the interests, inspiration, motivation and activities of students.

Teachers still taught conventionally because they did 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 was only as a facilitator and students who find their own concepts. So as to facilitate students actively participating in building the concept of Polyhedron. The material for constructing Polyhedron was suitable to be presented with contextual problems such as those already in the textbooks which are used only when an RME-based learning flow was needed that was designed in such a way as to develop students' concepts. Students needed a product that made them able to support learning that gave freedom to students in giving opinions and finding concepts by themselves so that learning became meaningful and would be able to be remembered for a long time. Likewise, with the teacher, it should use a teacher's book that was cable to be a guide in teaching in the classroom so that learning was more directed and matched with the student book.

3.5 literature Review

The activity was the analysis of theories and concepts relating to the development of the topic of flat side spaces. This activity was classified as a guide and consideration in designing the learning path of RME-based for polyhedron. The activities were reviewing research journals on learning paths and guidebooks which examine the development of Polyhedron.

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Kusumaningrum in her research increased the reasoning ability and independence of learning mathematics through RME in groups to improve mathematical reasoning abilities for junior high school students. This study showed that group learning with the RME approach could improve students' mathematical reasoning abilities, especially when solving mathematical reasoning abilities with indicators connecting real objects, pictures or diagrams into mathematical ideas [26].

Trisnawati in her study of the design of prism surface area learning materials using PMRI approach for grade VIII students with the learning flow made on the subject area of the prism surface with the contextual problem of the nets of the prism and calculating the area of each side, then summing these areas [27].

Based on a literature review of the learning flow of the topic of Polyhedron, overall the concept of building a flat side space must be presented to students through real world problems that can stimulate students in constructing their own concepts. Therefore, it was necessary to design a learning design topic to build a flat grid space with the RME approach.

4. Conclusion

Based on this preliminary research phase, it can be concluded as follows: 1) teachers were guided by printed books owned by teachers and students, which had not facilitated students to develop concepts through meaningful learning activities, 2) teachers also had not designed the right learning flow for teach a
mathematical topic 3) students’ mathematical reasoning ability was not optimal, 4). preparation of the learning flow will be in accordance with the results of curriculum analysis.

Based on the needs analysis, curriculum analysis, concept analysis, student characteristics analysis and literature review, it was necessary to design learning that can facilitate students to actively participate in discussing Polyhedron based RME on for grade VIII to improve students' mathematical reasoning abilities with a learning flow in the form of HLT and the product implementation of teacher's books and student books.

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