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# DESIGN OF POP-UP BOOK BASED ON REALISTIC MATHEMATICS EDUCATION TO IMPROVING SPATIAL ABILITY STUDENTS OF CLASS VIII

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**Abstract**

Spatial ability is about mentally manipulating things and their components and is considered critical for different domains such as science, technology, engineering, and mathematics, it was also can understand the relation and nature of geometry to solve mathematical problems in everyday life. This study aims to design teaching materials in the form of pop up books based on Realistic Mathematics Education (RME) to improve students' spatial ability in three-dimensional material. This type of research is the development research R&D (Research and Development) with the ADDIE model. This study discusses the design stage. The subjects of this study were teachers and students of eight-grade of Muhammadiyah Boarding School (MBS) Pleret Yogyakarta. The research data was obtained by interviewing to describe students' needs, and learning information used, as well as document analysis to analyze curriculum, learning materials, and teaching materials. Data analysis techniques use qualitative analysis. This study produced a pop-up book design that was in accordance with the analysis of student needs, student characteristics, curriculum, materials, learning methods, and teaching materials. Pop-up books are designed based on RME and are designed to improve students' spatial abilities. This research can be developed at the development, implementation, and evaluation.

**Keywords:** Pop-up book, Realistic Mathematics Education, spatial ability

## INTRODUCTION

Spatial ability is about mentally manipulating things and their components and is considered critical for different do-mains such as science, technology, engineering, and mathematics (Olkun, S., 2003). Moreover, Ekstrom et al. in Uttal, D. H. & Cohen, C. A. (2012) defined spatial visualization as modifying the image of spatial patterns into different forms. Linn, M. C., & Petersen, A. C. (1985) classify spatial abilities into three categories, namely spatial perception, mental rotation, and spatial visualization. National Academy of Science (2006) it was also stated that each student must try to develop his spatial abilities in understanding the relation and nature of geometry to solve mathematical problems in everyday life.

In the context of the curriculum, National Council of Teacher of Mathematics or NCTM (2000) has determined 5 content standards in mathematical standards, namely numbers and operations, problem-solving, geometry, measurement, and opportunity and data analysis. In geometry, there are elements of using visualization, spatial reasoning and modeling. This shows that spatial ability is a curriculum demand that must be accommodated in classroom learning. One branch of mathematics that is taught from elementary school to college and has a high level of abstractness is geometry (Özdemir, B. G., 2017). According to Guven and Cosa (2008), one standard given geometry in schools is so that children can use visualization, have spatial reasoning abilities and geometric modeling for problem-

solving. Therefore it is clear that spatial ability is very important in understanding geometry.

Spatial ability is also very closely related to academic achievement, especially mathematics. Cantürk-Günhan, Turgut, M., and Yılmaz, S. (2009) and Guay and McDaniel (1977) found that there is a positive relationship between spatial ability and mathematics learning achievement. Many studies suggest that most students at all levels have misconceptions about geometric concepts (Karakuş, F., & Peker, M., 2015). This also happened at MBS Pleret Yogyakarta which has a low average value in three-dimensional material. Based on the information and experience of the mathematics teacher at MBS Pleret Yogyakarta, students have difficulty imagining abstract buildings that are made visible, students often make mistakes in calculations because many students still misinterpret writing into images and vice versa, still incorrectly enter formulas and calculations. This is because students are more likely to memorize formulas and do not understand the concept of building space properly. Therefore, researchers provide solutions to improve students' spatial abilities so that students more easily solve problems related to building space by developing teaching aids such as Pop-Up Books.

Bluemel and Taylor (2012) suggest that the notion of the Pop Up Book is a book that displays the potential to move and its interaction through the use of paper as material for folds, rolls, shapes, patterns or turns. According to Qi and Buechley (2010), pop-ups are intrinsically three-dimensional and physically interactive. Figures and settings literally jump out of pages and pull-tabs and levers invite users to engage with the books in a variety of way. From some of the above meanings, it is clear that the Pop Up Book is a book that displays the impression of three dimensions in which there are elements of form and pattern that can give a real picture of abstract mathematical material in this case geometry.

In addition to teaching aids, mathematics learning needs an approach that supports abstract concepts that seem real, namely by using the Realistic Mathematics Education (RME) approach. Freudenthal philosophy of RME is mathematics as a human activity (Indriani, N & Hongki (2017); Peck, F (2015); Makonye, J. (2014)). In connection with the two views above (Gravemeijer, 1994), it should be cultivated near student life, and if it is real for the students. Students should be given free opportunities to learn to do mathematical or mathematical activities. RME is a mathematical learning approach that uses contextual problems so that teachers can equip students with logical, analytical, systematic, critical and creative thinking skills and student cooperative skills can be achieved (Noviani et al., 2017). Another opinion revealed 5 characteristics of RME, namely: using real-world contexts, using models, using production and construction, using interactions, and using linkages (Laurens et al., 2018). From the various characteristics above, the character of the RME that will be used in developing teaching materials is the real world context, using models, using production and construction, and using interactive methods. Based on the explanation above, the researcher intends to analyze the needs of mathematics learning teaching materials that are in accordance with the characteristics of students and design teaching materials that can improve spatial abilities.

Based on the background, the results of research, observations on students and interviews with mathematics teachers at Muhammadiyah Boarding School (MBS) in Pleret Yogyakarta, the problem arises that geometric mathematics books that are currently circulating are still in abstract and two-dimensional forms. Students are given material to build space with formulas and sample questions, which are then trained by students so that they are less skilled in imagining objects and spatial abilities are difficult to develop. So that requires three-dimensional books to practice spatial abilities and contextual problems that are appropriate for students so that students can build their knowledge not only driven by the formula. The selection of appropriate learning methods and media is needed in helping students understand the material being taught and is also expected to improve students' spatial abilities. But the problem now is that most teachers do not develop their teaching materials but use existing teaching materials and there is no renewal. The teaching materials available are not adapted to school conditions and student conditions. Based on this description, researchers are interested in developing Pop Up Books with the RME approach to improving students' spatial abilities in class VIII building materials. The purpose of this study is to produce a Pop Up Book design with the RME approach to improve students' spatial abilities.

## METHOD

This type of research is research and development. In the development of teaching aids in the form of Pop Up Book based on Realistic Mathematics Education (RME) in building material for class VIII SMP / MTs using ADDIE models as shown in Figure 1.

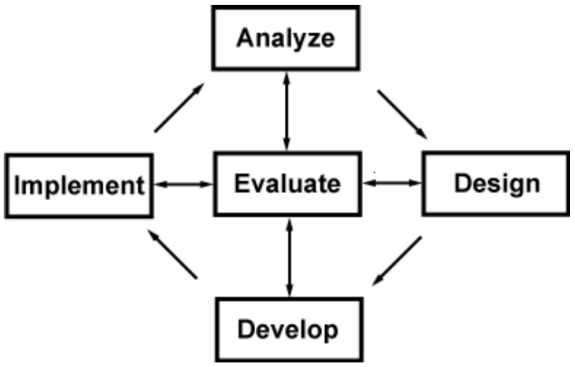


**Figure 1** ADDIE Model (B. A. Jones, 2007)

The development stages are analysis, design, development, implementation, and evaluation (B. A. Jones, 2007). The subjects of the trial in this study were grade VIII students and mathematics teachers at the MBS Yogyakarta Pleret. This research was limited to the design stage to determine the RME-based pop-up book design, the subject of building a flat side space. The data analysis technique used is qualitative data analysis. Data retrieval is done by using non-tests with research instruments in the form of interviews, observation, and document analysis. Interviews were conducted on teachers and students to find out data about students 'needs for RME-based Pop-Up Books and students' understanding of the concept of building space. Observation is done to find out the characteristics of students and learning methods in the learning process. While the document analysis was carried out to analyze the curriculum, learning materials, and teaching materials used. The data obtained is used as a reference in the development of RME-based Pop-Up Books.

## RESULT AND DISCUSSION

In this study, the results and discussion contained a description of the analysis and design stages because this study was only limited to the design stage.

### Analysis

At this stage, an analysis of the needs and requirements of the Pop-Up Book development is carried out. At this stage there are several analyzes, namely:

#### Analysis of the curriculum, teaching materials, and learning materials

The curriculum used in MBS Pleret Yogyakarta is the 2013 curriculum. According to interviews with teachers on MBS, the material for building teacher rooms uses worksheet as teaching material and uses conventional methods for learning. Regarding curriculum, the worksheet is in accordance with Basic Competencies along with indicators of its achievement. However, worksheet only displays two-dimensional elements while for space-building material whose essence has three-dimensional elements, a prop that displays these elements is needed and supports existing teaching materials.

#### Analysis of learning methods

Regarding methods, conventional learning methods are also not able to help students in understanding the concept of building space because there is no real approach to objects that are learned and impressed with everyday life. The analysis of the learning method resulted in the thought that the need for RME-

based Pop-Up Book was to facilitate students in imagining space-building objects that had three-dimensional elements so students would be easier to understand the concept of building space and understanding the problems to solve it.

**Analysis of student characteristics**

Based on the observations of the eighth-grade students of Pleret Middle School, the first students were less interested in learning mathematics so students were less focused and less concentrated on learning. Second, when the teacher explains the lesson, some students do not pay attention to the lesson, for example, students tell stories with their peers, some students sleep, and there are students who are busy with their own activities. Third, students only hear explanations from the teacher so students are not active in the process of learning. Based on the characters found, the researcher needs to use an approach that is able to encourage students to be active, students can explore, and students can find their own ideas. Therefore, the RME approach was chosen because it fits these characteristics.

**Analysis of student needs**

Based on information obtained from interviews with some eighth-grade students of the Muhammadiyah Boarding School (MBS) Middle School, when learning mathematics, they felt bored because learning tended to be monotonous and there was nothing new. Students and teachers are only motivated by market-bought worksheet containing subject matter, sample questions, and practice questions. Plus, the student worksheets used are less attractive, very few contain elements of images and colors so that it adds to student boredom and reduces students' interest in learning. From student interviews, students were also less able to understand the concept of building space because students claimed to have difficulty in imagining a building that was not real. For this reason, students need something tangible to study mathematics that seems abstract, especially in the matter of building space and supported by a realistic approach as well. Students also need something interesting and seemingly alive so learning becomes more fun. From the analysis of the needs of these students, researchers wanted to develop a teaching aid to complement and support the existing LKS in the form of a Pop-Up Book featuring three-dimensional elements based on the RME approach.

**Design**

At this stage, the design activities are carried out in the form of drafting in developing an RME-based Pop-Up Book. In making the Pop-Up Book it is divided into three parts [23] which are shown in Figure 2 below.

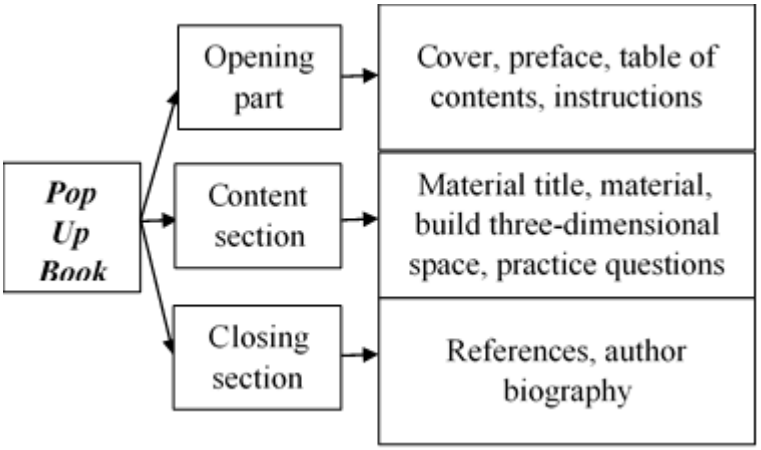


**Figure 2** An arrangement of the Pop-Up Book section

The design of this book uses pop-up techniques as one of the unique and distinctive features of this book. The pop-up technique used in this book is three dimensions and lift the flap. Initially Lift the flap was a technology created from paper material that was able to become a means for medical staff to explain how the anatomy of the human body, before the existence of more sophisticated technology like

today. Lift the flap has become increasingly developed with the strength of the technical characteristics that have always been maintained.

**Opening part**

The opening part of the pop-up book contains the cover, table of contents, introduction, and instructions for use. This section is compiled based on the results obtained from interviews and observations made to students. The opening section, especially the cover section, is arranged as interestingly as possible so that students feel attracted to the Pop-Up Book and feel happy in the learning done. The opening part of the Pop-Up Book is shown in Figure 3.

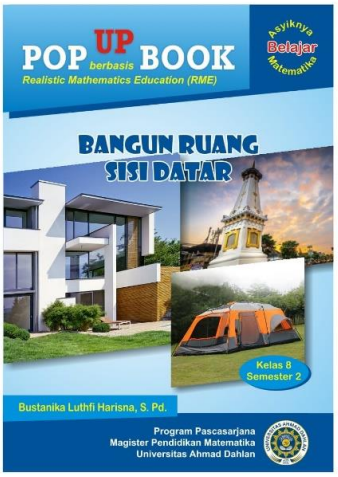


**Figure 3** Cover

The cover is designed with a blue background and with images of several buildings in it. Building drawings were chosen because they matched the approach used, namely RME. The RME approach refers to something tangible so that the construct of this space uses the buildings around us. For other opening parts, see Figure 4.


KATA PENGANTAR

Puji Syukur kehariat Allah yang maha kuasa, karena rahmat dan hidayahnya penulisan *pop up book* matematika ini dapat diselesaikan. *Pop up book* ini disusun sebagai salah satu sarana bahan ajar yang dapat digunakan dalam kegiatan belajar mengajar di sekolah.

Semoga dengan penulisan *pop up book* ini dapat membantu guru menyampaikan materi matematika kepada peserta didik serta membantu partisipasi aktif dalam melaksanakan pembaharuan bidang pendidikan.

Dalam *pop up book* ini disajikan materi pembelajaran matematika secara sederhana, efektif, dan mudah dimengerti yang disertai contoh dalam kehidupan sehari-hari siswa. Dalam *pop up book* ini juga disertakan tugas kelompok yang memicu siswa untuk mengetahui keterhubungan dunia nyata dengan matematika.

Adapun penulis telah mengusahakan semaksimal mungkin untuk menyelesaikan pembuatan *pop up book* ini. Namun tidak lepas dari semua itu, penulis menyadari sepenuhnya bahwa ada kekurangan baik dari segi penulisan bahasanya maupun segi lainnya. Oleh karena itu dengan lapang dada dan tangan terbuka bagi pembaca yang ingin memberi saran dan kritik kepada penulis sehingga penulis dapat memperbaiki *pop up book* matematika berbasis RME ini.

Yogyakarta, Oktober 2019

Penulis

POP UP BOOK MATEMATIKA KELAS VIII "BANGUN RUANG"

**Figure 4** Introduction

The colors used for the introduction of the background are adjusted to the color of the cover used. For the table of contents can be seen in Figure 5.

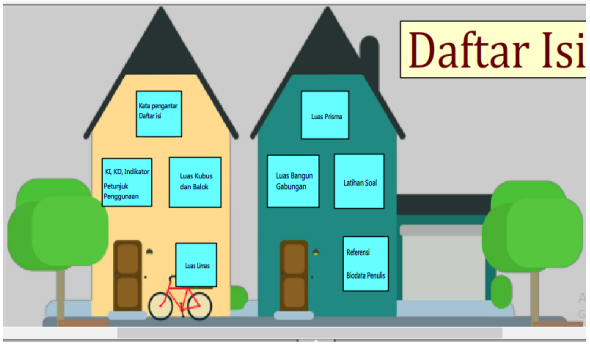


**Figure 5** Table of content

In the table of contents, the book design used is the lift the flap technique. If the paper in each chapter is opened, you will see a list of pages that correspond to the chapter.

**Content section**

The contents section contains chapter titles, basic competencies, core competencies, achievement indicators, learning activities steps, building three-dimensional space using three-dimensional pop-up techniques, material, and problem training. In the contents section, the characteristics included in the RME approach are the real-world context, using models, using production and construction, and using interactive methods. The real world context is the presentation of mathematics, not an abstraction but rather it is presented in a real or everyday way. In the use of the real world context, the material of building space is presented with objects in the real world that are cuboid, beam, prism and pyramid. Of course, the buildings are in the form of three dimensions. On the characteristics of the use of the model, this book presents various models of building space so students can immediately understand the various types of building space in the real world and everyday life. Production and construction mean making and building that is students make and build their own knowledge. In the use of production and construction students are asked to find any flat sheet that forms a building space and how to calculate the area of space and its combination. In this section, the design uses the lift the flap technique which is used as feedback for students' answers. If students want to know the correct answer, the students open the paper and the correct answer will appear. Students are also asked to determine the size of the combined space in the form of objects in real life presented in this book, for example, houses, tents, towers, and others. This book also presents problem exercises that are designed to be done in groups so that in this book characters from RME will emerge that are using methods of interaction or collaboration. The interaction referred to here is how students from one another work together to solve a problem. The contents section in this Pop-Up Book can be seen in the following picture.

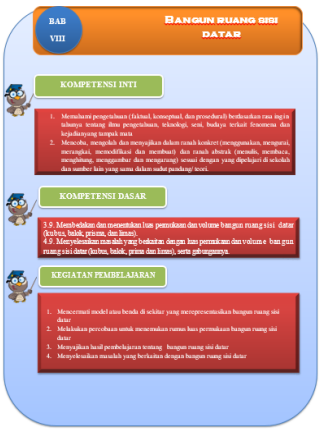


**Figure 6** Title of the material

The title of the chapter consists of Basic Competencies, indicators, learning objectives, and learning activities. The pop-up concept used can be seen in Figure 7.

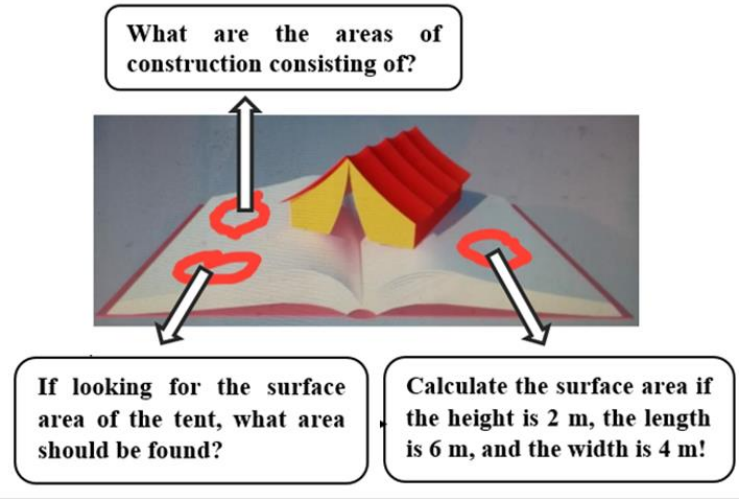


**Figure 7** Concepts

The concept of the Pop-Up Book used is a three-dimensional pop-up and lift the flap. In this Pop-Up Book, there will be a number of buildings such as tents, towers made of building stacked rooms, houses, and bathtubs. In each wake, students are asked to analyze what kind of space that composes a building and determines the surface area of the buildings by calculating the area of the flat building visible on the surface. That way students will find for themselves the concept of building surface area, especially the surface area to build a combined space. The next concept, problem training can be seen in Figure 8.


**Figure 8** Concepts

Question exercises are made abstract without cooling the object directly but only using words. This is to train students' spatial abilities in imagining objects that are abstract.

**Closing section**

The closing section of the Pop-Up Book consists of a glossary and bibliography. This research is limited only to the defining stages. However, to be clearer about the stages in ADDIE, it will be continued at the next stage, namely the development stage.

**Assessment and Revision**

Making a Pop-Up Book design is done sequentially including systematic presentation of design, suitability of material presentation with Basic Competencies, Pop-Up Book design containing elements of RME, design can foster spatial ability, and compatibility of images or illustrations used with the material presented. The initial design is the design of all activities carried out before the product is

developed. The results of the initial design of this product are the third development concept that will be carried out after the design is validated by experts. At the expert validation stage, an assessment is carried out to determine the validity of the Pop-Up Book design that will be developed. The Pop-Up Book design that has been approved by the supervisor is then validated by the validator, the teacher. The Pop-Up Book validation uses instruments in the form of questions and questionnaires that have been reviewed by lecturers. After a valid instrument can be used by experts to assess the Pop-Up Book design that will be developed. The expert consists of two people, namely Noor Aini, S.Pd. as a Mathematics Teacher at Kalasan Muhammadiyah Junior High School and Syah Fathi Azzatia, S.Pd. as a Mathematics Teacher at Taruna Al-Qur'an Yogyakarta Junior High School. The validator, in this case, does not revise the learning media. However, experts corrected the design that will be used in developing the Pop-Up Book. Following are some inputs and suggestions from experts summarized in Table 1.

**Table 1**. Results of Questionnaire Calculation Feasibility of Material

| Comments and Suggestions | Follow-Up |
|---|---|
| Some of the questions presented should use pictures with known sizes. | Provide clearer images and results on the questions presented. |
| The question questions presented must be consistent (command sentence / ask all or fill in all points). | Making questions is more consistent by changing the question into a whole question sentence. |
| Less of RME elements in the material presented. | It further clarifies the element of RME in the Pop Up Book. |

Input and advice from experts were revised. The following are the results of the questionnaire calculation regarding the feasibility of the Pop Up Book by the material experts showed in Table 2.

**Table 2** Questionnaire Calculation Results Feasibility of Media

| Assessors | Position | Score | Criteria for Quantitative Data |
|---|---|---|---|
| Noor Aini, S.Pd. | Mathematics study teacher at Junior High School Muh Kalasan | 88 | Very Good |
| Syah Fathi Azzatia, S.Pd. | Mathematics study teacher at Junior High School Taruna Al-Qur'an | 90 | Very Good |
| Total | | 178 | |
| Average | | 89 | Very Good |

Based on Table 2, it can be seen that the total score obtained is 178 with an average score of assessment is 89. So it can be concluded that the design of teaching materials in the form of Pop Up Book is included in the excellent category. After the Pop Up Book design is validated, the design is used as a reference for the development of teaching materials and is expected to develop students' spatial abilities.

## CONCLUSION

This research produced a pop-up book design that was designed based on curriculum analysis, materials, learning methods, teaching materials, student characteristics, and student needs to produce a Pop-Up book design based on Realistic Mathematics Education (RME). This Pop-Up book based on the RME approach aims to improve students' spatial abilities. The pop-up book design component consists of a cover, introduction, table of contents, usage instructions, basic competencies, core competencies, achievement indicators, three-dimensional space development, and problem training. This pop-up book contains the characteristics of RME, namely the real-world context, using models, using production and

construction, and using interactive methods. To develop this book, researchers will conduct further research at the development stage. Based on the results of the validation of the Pop Up Book design produces an average score of 89, which means that a decent design is developed into a Pop Up Book for learning. The Pop Up Book design developed is expected to improve students' spatial abilities.

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