Development of Polyhedron Teaching Materials Based on Realistic Mathematics Education Approach to Improve Students' Mathematical Understanding

Adilah Juliana Rosa[1]; Wiwit Damayanti Lestari*[2]; Mochammad Taufan[3]; Mellawaty[4]
[1,2,3,4]Departement of Mathematics Education, Faculty of Teacher Training and Education, Universitas Wiralodra
adilajulianar7@gmail.com[1], wiwitdamayantilestari@unwir.ac.id[*2], mochammad.taufan@unwir.ac.id[3], mellawaty@unwir.ac.id[4]

Abstract

This research aims to find out whether the Realistic Mathematic Education approach-based polyhedron teaching materials that were developed achieve the criteria for being suitable for use and to find out whether teaching materials based on the Realistic Mathematic Education approach can improve students' mathematical understanding abilities. This type of research is research and development (R&D) using development procedures which include: Define, Design and Develop. Data collection used instruments for the appropriateness of teaching materials by teachers and lecturers, and instruments for understanding the concept of polyhedron. The results of research on teaching materials according to experts show that the teaching materials developed have very feasible criteria with an average score of 4.48. The test results for the ability to understand mathematical concepts showed an increase with an average score of 0.64.

Keywords: *Development Of Teaching Materials; Realistic Mathematic Education Approach; Mathematical Understanding; Research and Development.*

Abstrak

Penelitian ini bertujuan untuk mengetahui apakah bahan ajar bangun ruang sisi datar berbasis pendekatan *Realistic Mathematic Education* yang dikembangkan mencapai kriteria layak pakai dan untuk mengetahui apakah bahan ajar materi bangun ruang berbasis pendekatan *Realistic Mathematic Education* dapat meningkatkan kemampuan pemahaman matematis siswa. Jenis penelitian ini adalah penelitian dan pengembangan atau research and development (R&D) dengan menggunakan prosedur pengembangan yang meliputi: *Define* (Pendefinisian), *Design* (Perancangan), dan *Develop* (Pengembangan). Pengumpulan data menggunakan instrumen kelayakan bahan ajar oleh guru dan dosen, dan instrumen pemahaman konsep bangun ruang sisi datar. Hasil penelitian pengembangan bahan ajar menunjukan bahwa hasil penelitian bahan ajar menurut para ahli menunjukan bahwa bahan ajar yang dikembangkan memiliki kriteria sangat layak dengan perolehan rata-rata 4,48. Hasil tes kemampuan pemahaman konsep matematis menunjukan peningkatan dengan rata-rata skor 0,46.

Kata Kunci: Pengembangan Bahan Ajar; Pendekatan *Realistic Mathematic Education*; Pemahaman Konsep Matematis; Penelitian dan Pengembangan.

*Correspondence:
Email: wiwitdamayantilestari@unwir.ac.id

INTRODUCTION

Education acts as an instrument capable of developing various areas of human life, including technological development, social interaction, trade, culture and overall progress of the nation (Ilham, 2019). Education does not only focus on teaching science to students, but more essentially is increasing students' intellectual capacity and providing direction to students, teachers and society in general to understand the relationship between education and the progress of a nation (Hai, 2021).

The role of education has enormous importance in human life, so that it becomes a benchmark for the progress of a nation. However, the government faces major challenges in improving the quality of education because basically the quality of education in Indonesia is still considered low (Fauzi et al, 2018). One way to improve the quality of education is through continuous reform in the field of education, especially in mathematics subjects (Ulandari et al., 2019).

This is because mathematics is a basic science for many professions, especially science, technology and engineering (Li & Schoenfeld, 2019). In line with the perspective presented by Ibrokhimovich & Qizi (2022), mathematics in general has great importance and is very relevant in everyday life. In fact, mathematics is always involved in various aspects of our lives, especially when we face challenges in solving various problems that require skills in explaining logically and carrying out calculations accurately. Mathematics basically has a very important and essential value in everyday life, which aims to provide knowledge and skills in using and applying abilities in solving problems in real life situations.

However, the majority of students consider that mathematics is the most difficult subject and many of them face difficulties in learning mathematics (Acharya, 2017). Apart from that, students also think that the difficulties they experience when learning mathematics are caused by the complexity of the mathematics problems which they feel are very difficult for them to overcome (Laurens et al., 2018). Ndiung et al., (2019) also stated that one of the factors causing students' weak understanding and logical skills in learning mathematics is

because there are still many teachers who only focus on teaching formulas and methods, so that students have difficulty developing their own thinking abilities.

In situations like this, students' interest in learning mathematics decreases, especially in geometric material. This is based on the results of interviews with mathematics teachers at a junior high school in Indramayu. According to the results of the interview, class VII students experienced difficulties in understanding spatial figures, especially in the ability to imagine three-dimensional objects and a lack of accuracy in applying formulas, especially in combined spatial figures, as well as the use of conventional textbooks which were also considered difficult for students to understand. material presented.

The results of previous research show that students' understanding of spatial shapes is low, students face difficulties in the subject of spatial shapes, especially in determining surface area correctly (Magdalena et al, 2020). What we need to realize is that there are a number of factors that contribute to students' disinterest in learning to build space. One of the most significant factors is the teaching method applied by the teacher in the classroom. Unfortunately, students often feel that this method lacks variety, making them feel bored and unmotivated to learn the material. So, the teacher's role in making the teaching and learning process more interesting and interactive is very important to encourage students' interest in learning, especially in building materials (Chintia et al, 2021).

Teaching materials are learning tools that present learning topics systematically, thereby producing comprehensive understanding and functioning to transfer knowledge to students (Rini et al., 2019). In the learning process, the role of teaching materials is much more significant than the curriculum (Magdalena et al, 2020). Lianghou Fan stated that teaching materials have a very important role in the student learning process and also the teacher's teaching process (Alim et al., 2021). Student learning outcomes are greatly influenced by the teaching materials used during the learning process, as well as the teacher's decisions in choosing teaching materials and teaching strategies (Yolanda, 2020). Regular improvements and updates are needed in teaching materials so that the learning process can reach an optimal level (Hatane et al, 2021).

Mathematics learning should be based on and relevant to human activities in real life, especially in students' daily contexts (Taufina et al., 2019). Therefore, to help students understand mathematical concepts, it is important for us to integrate effective learning approaches or models, namely by linking the material being taught to real situations or conditions that exist in students' daily lives. One strategy that can be used to achieve this goal is to design teaching materials based on Realistic Mathematic Education. Realistic Mathematical Education is an educational method designed with the specific aim of teaching mathematical concepts by relying on the experiences experienced by students. That way, this method can make it easier for students to understand these concepts. This approach utilizes real situations as a learning context, so that students can understand and apply mathematical concepts in real situations, making learning more meaningful and effective for students (Zakaria & Syamaun, 2017).

Adopting a realistic approach in the mathematics learning process has a very fundamental aim, namely to facilitate students in making connections between the material they learn in class and real life situations, or in other words, things that they can directly observe and understand. easily through their observation and interpretation of the situation in the surrounding environment (Sedaryati, 2020).

The basic principle of this approach is to enable students to imagine and visualize mathematical concepts in real life contexts, not just as a collection of numbers and abstract formulas on a whiteboard. With an approach like this, students can imagine real situations or objects related to the mathematical concepts being studied. Thus, the aim of applying this realistic approach is basically to help facilitate the process of students' understanding of mathematics learning material. This is in line with learning principles that prioritize conceptual understanding over memorization. With good understanding, it is hoped that students can apply their mathematical knowledge in various real life situations more effectively and efficiently (Sedaryati, 2020).

The use of the Realistic Mathematic Education (RME) approach in mathematics learning has a great opportunity to help students improve their mathematics skills in various dimensions. Thus, the RME approach can be the right solution to overcome a number of problems that exist in mathematics learning, and can help students to gain a more comprehensive understanding of the material. Therefore, developing and implementing learning materials based on the RME approach is important and must be done. This aims to enable students to gain broader and deeper mathematical knowledge, which is not only limited to conceptual understanding, but also its application in real life contexts. It is hoped that the stages in RME-based teaching materials can complement and facilitate students to be able to learn independently. The aims of this research is, to find out whether the Realistic Mathematic Education approach-based polyhedron teaching materials that were developed achieve the criteria for being suitable for use and to find out whether teaching materials based on the Realistic Mathematic Education approach can improve students' mathematical understanding abilities.

RESEARCH METHODS

This research is research and development (R&D) which involves the process of conducting research, designing, manufacturing and testing product acceptance (Sugiyono, 2015). In the framework of creating teaching materials, this research adopts the 4-D model which consists of the stages of determining, designing, developing and disseminating, but in this research it only reaches the development stage, this is due to the author’s limited time to carry out this dissemination.

The test subjects in this research were validator test subjects and product test subjects. The test subjects for expert validators on teaching materials were 1 lecturer majoring in mathematics education at Wiralodra Indramayu University and 3 mathematics subject teachers at SMPN 1 Arahan. Subject experts are tasked with assessing the suitability level of teaching material products. The product trial subjects were 6 class VIII students at SMPN 1 Arahan with the criteria for high, medium and low students. There are two instruments in this research, including an

expert validation instrument and a test instrument for understanding the concept of polyhedron. Data collection techniques in this research include (1) interviews; (2) questionnaire and (3) test.

There are two data analysis techniques in this research, including:

1. Analysis of Expert Validation Instrument Data

Qualitative data in this research consists of the results of filling in validation sheets and practicality assessment sheets by lecturers and teachers. This data is classified into five selected categories using a 1 to 5 rating scale, with a score of 1 being the lowest score and a score of 5 being the highest score. To analyze the data with the five selected categories, grouping was carried out based on the qualifications of the products being assessed. Next, the average score obtained from each category was entered into the qualitative category according to Table 1 which was adapted from Habiby (2017).

Table 1. Criteria for Quantitative Data to Qualitative Data

Formula	Score Interval	Criteria
$(\bar{x} + 1.8 \times sbi) < x$	$4.2 < x$	Very Appropriate
$(\bar{x} + 0.6 \times sbi) < x \leq (\bar{x} + 1.8 \times sbi)$	$3.4 < x \leq 4.2$	Appropriate
$(\bar{x} - 0.6 \times sbi) < x \leq (\bar{x} + 0.6 \times sbi)$	$2.6 < x \leq 3.4$	Pretty Appropriate
$(\bar{x} - 1.8 \times sbi) < x \leq (\bar{x} - 0.6 \times sbi)$	$1.8 < x \leq 2.6$	Not Appropriate
$x \leq (\bar{x} - 1.8 \times sbi)$	$x \leq 1.8$	Bad

If the validity score of each teaching material meets the minimum valid category, then the teaching material is considered valid for use in trials. However, if the results of data analysis show that the validity score does not reach the expected valid level, then the data will be taken into consideration to revise the product before further testing is carried out.

2. Data Analysis Understanding the Concept of Polyhedron

In this research, one of the data analysis techniques implemented is the use of N-gain. This technique is used as a tool to obtain results from students' tests of understanding mathematical concepts. This N-gain score was designed with a

specific aim, namely to assess the effectiveness of the method or treatment used in this research. In other words, the N-gain score helps in knowing whether the method or treatment chosen in this research is successful in achieving the stated objectives or not. To achieve this, the N-gain method is carried out by calculating the difference between the scores obtained before and after the treatment or test is carried out, which is often referred to as the pretest and posttest. This difference in value is then used to determine how effective the method or treatment used is. Furthermore, the N-gain score, also known as normalized gain, is calculated using a special formula. We can calculate the normalized gain or N-gain score using the following formula:

$$N - gain = \frac{posttest\ value - pretest\ value}{maximum\ value - pretest\ value}$$

Note: The ideal score is the maximum (highest) value that can be obtained.

After obtaining the N-gain score, the N-gain Score category is obtained. The normalized N-gain Score results are divided into three categories (Sudiyono, 2003), as in table 2, below:

Table 2. N-gain Criteria

N-gain value	Interpretation
$< g >\geq 0.7$	High
$0.7 < g >\geq 0.3$	Average
$< g >\geq 0.3$	Low

RESULTS AND DISCUSSION

The results of the development of polyhedron teaching materials based on the Realistic Mathematic Education approach with development procedure through 3 steps, namely Define, Design, and Develop. First, an initial analysis is carried out to determine the basis for development. Next, student analysis is carried out to understand the characteristics and needs of students in the learning process. Then, a task analysis is carried out to identify relevant tasks. After that, a concept analysis was carried out to formulate an in-depth understanding of the material for polyhedron. With this understanding, learning objectives can be formulated clearly and specifically. The results of this research are teaching

materials based on Realistic Mathematic Education which are presented in the form of a book on polyhedron. Next, teaching materials and assessments are designed which will be tested by expert validators. This process is important to ensure the quality and effectiveness of the teaching materials that have been prepared. In line with the results of research conducted by Putri (2020) that the application of RME-based teaching materials has a big influence on students' ability to understand mathematical concepts, because these teaching materials are tools that help students understand concepts and students given material that is related to real life which will foster enthusiasm for learning.

The teaching materials that have been designed are then assessed by expert validators. Teaching materials will be considered appropriate if they meet the assessment criteria established during the validation process. Therefore, the process of developing learning materials aims to ensure that material about Polyhedron is delivered in an effective and useful way for students. The learning material that has been formulated based on the findings of this research has gone through a validation process carried out by expert validators. From this assessment, the results show that the learning material is very suitable and suitable for use in the educational process. This means that the approach taken in designing and developing this material has been successful in creating a appropriate and effective learning resource.

The average score from the expert assessment results is 4.48. In terms of appropriateness of content, the average score reached 4.44 with very appropriate criteria, indicating that the material presented in the teaching materials is in accordance with the applicable Core Curriculum (KI) and Basic Competencies (KD) as well as in accordance with the Realistic Mathematic Education approach is very appropriate.

Table 3. Results of Teaching Material Assessment by Expert Validators

Rated Aspect	$\bar{x}$	Criteria
Appropriateness of content	4.44	Very Appropriate
Language	4.45	Very Appropriate
Presentation	4.33	Very Appropriate
Display design	4.67	Very Appropriate
Overall	4.48	Very Appropriate

In terms of linguistic aspects, teaching materials have achieved an average score of 4.45 with the criteria "very appropriate", which shows that the language used in the learning materials is clear and easy for students to understand. The presentation of material in teaching materials also received positive appreciation, with an average score of 4.33 which is included in the "very appropriate" criteria, which reflects that the material is prepared systematically and well structured. Regarding the agricultural aspect, teaching materials were also successful in getting an average score of 4.67 which is included in the "very appropriate" criteria. The visual design of the teaching materials is also considered appropriate and attractive. In general, the evaluation results from experts confirm that the teaching materials that have been prepared have reached high quality standards and are very suitable for use in the teaching and learning process of Polyhedron. The following is a discussion of teaching materials before revision and after revision, can be seen in Figure 1.

The teaching material trial was used by 6 students with the criteria of high, medium and low students. The results of the test for the ability to understand the concept of Polyhedron show that the average N-gain score is 0.64, which is included in the quite effective category with a minimum score of 0.58 and a maximum score of 0.73.

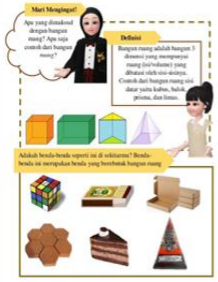
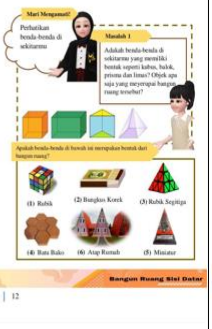
Table 4. N-Gain Results of Trial Subjects

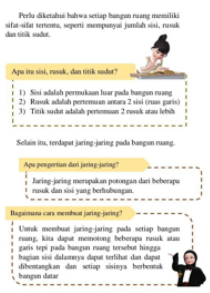
Number	N-gain Value	Interpretation
1	0.59	Average
2	0.59	Average
3	0.69	Average
4	0.58	Average
5	0.73	High
6	0.67	Average

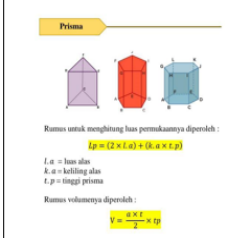
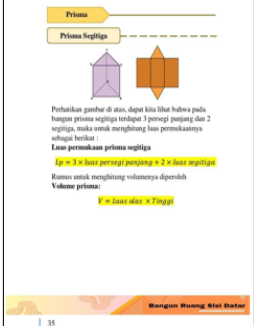
Table 5. Average N-gain of Trial Subjects

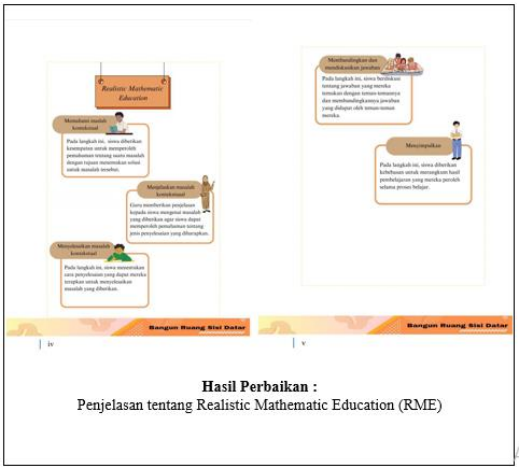
	N	Minimum	Maximum	Mean	Std. Deviation
N-gain	6	.58	.73	.6408	.06446
Valid N (listwise)	6				

Sebelum Revisi	Sesudah Revisi
	
Saran : Cover masih kurang realistik	**Hasil Perbaikan** : Cover sudah diperbaiki dengan menampilkan gambar yang realistik.

Sebelum Revisi	Sesudah Revisi
	
Saran : Penyajian buku ditambahkan interaksi terkait pemberian stimulus dan responnya agar pembaca dapat membangun pola pikir tentang pemahaman konsep.	**Hasil Perbaikan :** Penyajian materi sudah diperbaiki dengan menyajikan stimulus dan respon.

Sebelum Revisi	Sesudah Revisi
	
	Hasil Perbaikan : Penjelasan materi diperbaiki dengan menampilkan langkah-langkah RME.

Sebelum Revisi	Sesudah Revisi
	
Saran : Sederhanakan rumus-rumus dengan kata-kata yang sederhana atau mudah dipahami oleh siswa.	**Hasil Perbaikan :** Rumus-rumus sudah disederanakan dengan mengganti kalimat menggunakan kalimat yang lebih mudah dipahami.



Hasil Perbaikan :
Penjelasan tentang Realistic Mathematic Education (RME)

Figure 1. Discussion of Teaching Materials Before and After Revision

Table 5 shows that the average N-gain score is 0.64, which is in the quite effective category with a minimum score of 0.58 and a maximum of 0.73. So it can be concluded that the use of spatial construction teaching materials based on the Realistic Mathematic Education approach can improve students' ability to understand concepts.

Thus, it was found that the use of teaching materials about Polyhedron based on the Realistic Mathematics Education approach can improve students' conceptual understanding of the material, making it suitable for use in the learning process. This research is in line with a study conducted by Putri (2020), which states that the use of mathematics teaching materials using the Realistic Mathematics Education approach has a significant influence on students' ability to understand mathematical concepts. This is due to the approach used in these teaching materials, which helps students to better understand mathematical concepts. In addition, teaching materials with a Realistic Mathematics Education approach present material that is relevant to real life, making it easier for students to connect mathematical concepts with situations and contexts they are familiar with. Thus, this generally encourages students' enthusiasm for learning, because they can see the relevance and benefits of what they learn in everyday life. Another study conducted by Sari & Yuniati (2018), also found that there were differences in the ability to understand mathematical concepts between students who studied using the Realistic Mathematics Education approach and students who studied using conventional methods. The limitation of this research is that in this research the development research stage was carried out only up to the development stage, for further research it can be continued to the teaching materials distribution stage.

CONCLUSION

Based on the explanation outlined previously, it can be concluded that teaching materials developed based on the Realistic Mathematics Education approach can achieve the criteria for being suitable for use and can improve students' mathematical understanding abilities.

REFERENCES

Alim, J. A., Hermita, N., Alim, M. L., Wijaya, T. T., & Pereira, J. (2021). Developing a Math Textbook using realistic Mathematics Education Approach to increase elementary students' learning motivation. *Jurnal Prima Edukasia*, *9*(2), 193-201.

Chintia, M., Amelia, R., & Fitriani, N. (2021). *Analisis Kesulitan Siswa Pada Materi Bangun Ruang Sisi Datar*. JPMI, *4*(3), 579-586.

Hatane, S. E., Setiono, F. J., & Setiawan, F. F. (2021). Learning environment, students' attitude and intention to enhance current knowledge in the context of choosing accounting career. *Journal of Applied Research in Higher Education*, 13(1), 79-97.

Fauzi, A., Waluya, S. B., & Masrukan. (2018). *Math Learning with Realistic Mathematics Education Approach (RME) Based On Open Source-Ended to Improve Mathematic Communication*. JPE, *7*(1), 10-17.

Habiby, W. N. (2017). Statistika Pendidikan. Surakarta: Muhammadiyah University Press.

Hai, Y. (2021). Poverty Alleviation by Education is A Kind of Awakening and Discovery: In Memory of the 'Poverty Alleviation War' of a Retired Middle School Principal in Eastern China. *Science Insights Education Frontiers*, *8*(2), 1097-1107.

Ilham, D. (2019). Menggagas Pendidikan Nilai dalam Sistem Pendidikan Nasional. *Didaktika: Jurnal Kependidikan*, *8*(3), 109-122.

Ibrokhimovich, F. J & Qizi, A. M. F. (2022). Teaching Mathematics in Elementary School : Issues and Solutions. *Eurasian Journal of Learning and Academic Teaching*, *4*, 84-87.

Laurens, T., Batlolona, F. A., Batlolona, J. R., & Leasa, M. (2018). How does realistic mathematics education (RME) improve students' mathematics cognitive achievement?. *Eurasia Journal of Mathematics, Science and Technology Education*, *14*(2), 569-578.

Li, Y., & Schoenfeld, A. H. (2019). Problematizing teaching and learning mathematics as 'given' in STEM education. *International Journal of STEM Education*, *6*(1), 1-13.

Magdalena, I., Prabandani, R. O., Rini, E. S., Fitriani, M. A., & Putri, A. A. (2020). Analisis Pengembangan Bahan Ajar. *NUSANTARA*, *2*(2), 180-187.

Ndiung, S., Dantes, N., Ardana, I. M., & Marhaeni, A. A. I. N. (2019). Treffinger creative learning model with RME principles on creative thinking skill by considering numerical ability. *International Journal of Instruction*, *12*(3), 731-744.

Acharya, B. R. (2017). Factors Affecting Difficulties in Learning Mathematics by Mathematics Learners. *International Journal of Elementary Education*, *6*(2), 8-15.

Putri, L. S. A. (2020). Penerapan Bahan Ajar Realistic Mathematics Education (RME) Terhadap Kemampuan Pemahaman Konsep Matematis Siswa. Jurnal Peka: Jurnal Pendidikan Matematika, 4(1), 27-29.

Rini, A. P., Suryani, N., & Fadhilah, S. S. (2019). Development of the Predict Observe Explain (POE)-based Thematic Teaching Materials. *International Journal of Educational Research Review*, *4*(1), 1-7.

Sari, A & Yuniati, S. (2018). Penerapan Pendekatan Realistic Mathematics Education (RME) Terhadap Kemampuan Pemahaman Konsep Matematis. Jurnal Cendekia: Jurnal Pendidikan Matematika, 2(2), 71-80.

Sedaryati, S. S. (2020). *Penerapan Bahan Ajar Matematika Berbasis Realistic Mathematic Education (RME) Terhadap Kemampuan Pemahaman*. Jurnal Peka: Jurnal Pendidikan Matematika, *4*(1), 1-8.

Sudiyono, A. (2000). Pengantar Statistik Pendidikan (Cetakan X). Jakarta: PT. Raja Grafindo Persada.

Taufina, T., Chandra, C., Fauzan, A., & Ilham Syarif, M. (2019). *Development of Statistics in Elementary School Based RME Approach with Problem Solving for Revolution Industry 4.0*. *382*(Icet), 716-721.

Ulandari, L., Amry, Z., & Saragih, S. (2019). Development of Learning Materials Based on Realistic Mathematics Education Approach to Improve Students' Mathematical Problem Solving Ability and Self-Efficacy. *International Electronic Journal of Mathematics Education*, *14*(2), 375-383.

Yolanda, Y. (2020). Development of Contextual-Based Teaching Materials in The Course of Magnetic Electricity. *Thabiea: Journal of Natural Science Teaching*, *3*(1), 59-69.

Zakaria, E., & Syamaun, M. (2017). The Effect of Realistic Mathematics Education Approach on Students' Achievement And Attitudes Towards Mathematics. *Mathematics Education Trends and Research*, *2017*(1), 32-40.