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Development of Realistic Mathematics Education-Based Learner Worksheets (LKPD) to Enhance Higher-Order Thinking Skills in Grade IV Students of SD/MI

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ABSTRACT

This study aims to determine the development procedures, feasibility, and effectiveness of mathematical worksheets based on realistic mathematics education to develop high-order thinking skills of fourth-grade students in SD/MI. This research is a research and development (R&D) research using a 4D research model consisting of 4 stages, namely the Define, Design, Development, and Disseminate. The data instruments used in this study were interview observations. The subjects of this study were the fourth-grade students of SDN Sukatani VI, totaling 35 students. The data analysis was qualitative and quantitative. Qualitative data analysis was obtained from observations and interviews, while quantitative data analysis was obtained from expert validation, teacher response questionnaires, and student response questionnaires. The validation results of mathematic education experts, with a percentage of 83%, were categorized as "Good/Valid". Based on the teacher's response, the research results obtained 96% categorized as "Very Good/Decent," and student responses obtained by the assessment results with a percentage of 90.28% categorized as "Very Good" to use. From the results of development trials to assess effectiveness with pretest and posttest get a score of 88.5 above the KKM or a percentage of 82.8% can be categorized as "Very Effective" to use, as well as the recapitulation of pretest and posttest results using the N-Gain test got a score of 0.82 students experienced the development and improvement of learning outcomes.

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INTRODUCTION

The learning process in Curriculum 2013 (K13) is a student-centered learning process where students are active in learning and contextual in nature. This causes the need for students to prioritize personal experience through observation (seeing, reading, listening, and listening), socializing, questioning, concluding, and communicating. (Zulainy et al., 2021).. According to the Ministry of Education and Culture, the purpose of learning mathematics is to train students' intellectual abilities, especially high-level thinking skills, the ability to solve student problems systematically, the ability for high learning outcomes, the ability to generate ideas to develop communication skills, and student characteristics.

One of the learning objectives of mathematics is the ability to think at a high level or High Order Thinking Skills (HOTS). The definition of HOTS or High Order Thinking Skills is a change in the concept of education based on the rules and principles of learning. The importance of this

understanding is that learning mathematics requires more cognitive processing (knowledge) than others, but it also has many benefits for the public. The efforts made by the Ministry of Education and Culture that are currently being carried out are expected to improve students' ability to absorb mathematics material at school. [2].

According to Brookhart, HOTS has three interrelated things, namely transference, critical thinking, and problem-solving. The purpose of transference is to enable students to apply what they have learned to their lives. Critical thinking is the ability to think rationally and introspectively and focuses on deciding whether or not to believe or act on something. Problem-solving is the ability of students to use what they already have to solve previously undiscovered (non-routine) problems. [3]. High-demand thinking ability is not only the ability to remember, know, and repeat but the ability to handle problems (critical thinking), decisive reasoning ability (decisive reasoning), inventive reasoning (innovative reasoning), reasoning ability (thinking), and the capacity to decide (navigation). [3]. From the above, higher-order thinking skills are very important in student mathematics learning.

HOTS assessment in mathematics learning is conducted to survey students' abilities in the domains of examining (C4), assessing (C5), and creating (C6). The questions used to measure HOTS evaluation must be tailored to the needs of assessing the right level of reasoning so that they are not flawed, meaning that the questions to be made are any questions and questions that have attributes including non-algorithmic, will generally be confusing, have settings that may be multiple (unconditional methodology), and expect work to track unpredictable design [4]. Problems that have these properties will inspire students to parse, assess, and make expected paths to deal with problems. In accordance with the Department of Education and Culture (2017) in the HOTS evaluation rules, it has been explained that HOTS questions are truly assessment-based assessments in everyday life, where students are expected to apply ideas learned in class to solve problems.

Based on observations made by researchers from several schools in Sukatani Village, namely SDN Sukatani VI and SDS Da'arut Taqwa for class 4 (IV), it was found that students' high-level thinking skills were still low, such as critical thinking, creative & innovative thinking, communication skills, cooperation skills, and self-confidence skills. The learning process of both schools still tends to be teacher-centered, where students are given formulas of subject matter instantly by the teacher so that the thinking skills acquired by students are only remembering (C1), understanding (C2), and applying (C3). When the teacher asks different questions but the meaning of the formula is the same, students feel confused because students have been indoctrinated by the formula taught by the teacher instantly and are not given the opportunity to have higher-level thinking skills to analyze (C4), evaluate (C5), and create/creative (C6). [5].

From the observations made by researchers from the two schools, students' learning activities still use one printed LKS book from the publisher's service, and this LKS is not made independently by the teacher. The student learning system only records what the teacher has written on the blackboard, and the teacher then explains it. Students ' questions are also taken from the printed LKS book the school purchased. This can make it difficult for students to understand the material provided by the teacher during the learning process. Other obstacles encountered by teachers in familiarising students with the concept of HOTS in mathematics learning are a limited time to develop HOTS questions, lack of understanding in finding and matching HOTS questions, inaccurate selection of KD, lack of socialization about making HOTS questions and still making questions with the same model.

As a result, students cannot develop higher-order thinking skills when learning mathematics.

To overcome these problems, learning innovations that are meaningful to students are needed, and higher-order thinking skills must be trained and developed. This is one of the advances and options in learning mathematics that allows students to think at a higher level, for example, breaking down, assessing, and making students create Learning Worksheet materials (LKPD).

LKPD is one of the means of supporting and facilitating teaching and learning activities, creating an effective interactive format between students to increase student activity and improve learning achievement results. [6]. LKPD has several advantages, namely training students' critical thinking, developing process skills in students, making it easier for teachers to provide teaching materials, training students to collaborate independently, and helping students understand a concept.

The development of LKPD in SD/MI requires an interesting and realistic learning model for students. One of the learning models that can be applied to the 2013 curriculum and provide contextual issues is Realistic Mathematic Education, developed by Hans Freudenthal in 1971. According to Hans Freudenthal, "Mathematics is a form of human activity". The purpose of mathematical activities here is human activities, which include finding problems, organizing problems, and solving problems. [7]. RME (Realistic Mathematic Education) is an object-based mathematics learning approach that uses and optimizes everyday experiences to develop students' critical thinking skills when learning mathematics. RME-based mathematics learning activities have five steps: understanding contextual problems, comparing & discussing answers, and concluding [8].

Therefore, to improve the implementation of RME in the learning process, it is necessary to develop RME-based mathematics LKPDs as teaching materials. This means that mathematical concepts are associated with practical concepts in students' daily lives. RME-based LKPDs are made by initiating problems related to the real world of students. Through real-world problems in students' daily lives, students can find the concepts or principles learned and can develop higher-order thinking skills. The development of RME-based mathematics LKPD is important to develop the ability to analyze, evaluate, and create mathematical problems in accordance with the daily lives of students in real terms. Based on the description above, the researcher plans to conduct research with the title "Development of Realistic Mathematic Education-Based Mathematics LKPD to Develop Higher-Level Thinking Skills of Grade IV Students in SD / MI".

METHODS

The research method used in this research is research and development (Research and Development) using the 4D model, which consists of defining, designing, developing, and disseminating. [9]. The location of the study conducted by the researcher was SDN Sukatani IV Kel. Sukatani, Kec. Rajeg, Kab. Tangerang, Banten Province. The subjects of this research are grade IV students of SDN Sukatani IV, totaling 35 students. The object of this research is the RME-based mathematics LKPD to develop higher-order thinking skills in students.

The data collection techniques used by researchers are observation, interviews, questionnaires/surveys, and tests. Observations were conducted directly in the classroom to see how the learning process took place and to observe the interactions between the teacher and the students. This allowed the researchers to gain insights into the actual teaching and learning dynamics.

Interviews were conducted with teachers and students to obtain in-depth information about their views on mathematics learning and the use of RME-Based LKPD. These semi-structured interviews aimed to understand the participants' experiences and opinions regarding the implementation of the developed worksheets. The interviews provided qualitative data that were crucial for understanding the context and effectiveness of the teaching materials.

To gather quantitative data, the researchers used questionnaires that included both closed and open-ended questions. The teacher questionnaire focused on various aspects such as didactic, construction, technical aspects, content appropriateness, HOTS aspects, RME aspects, design, and language. This comprehensive questionnaire aimed to cover all relevant dimensions of the teaching materials. The student questionnaire measured the level of satisfaction and understanding of the material presented through the LKPD, providing essential feedback from the primary users of the worksheets.

The effectiveness of the developed LKPD was measured using tests, specifically pretests and posttests. These tests were designed to assess the improvement in students' higher-order thinking skills before and after using the RME-based LKPD. The results of these tests were analyzed using the N-Gain test to determine the difference in scores between the pretest and posttest, thus providing a clear measure of the impact of the teaching intervention.

The data analysis technique used involved validating the product using questionnaires filled out by mathematics education experts, as well as collecting responses from teachers and students. The validation process ensured that the LKPD met high-quality standards and was suitable for use in the classroom. To test the effectiveness of the developed product, the pretest and posttest results were analyzed, and the test results were recapitulated using the N-Gain test [10].

RESULTS AND DISCUSSION

In this research and development, researchers developed a product in the form of RME-based mathematics LKPD to develop higher-order thinking skills of grade IV students in SD / MI with the material of the perimeter of flat shapes (square, rectangle, and triangle). This product development goes through several stages, namely defining, designing, developing, and disseminating. The following is a more detailed discussion related to each of these stages.

1. Define

This stage consists of several stages, namely front-end analysis (initial analysis), student analysis, task analysis, and concept analysis [11].

a. The front-end analysis at this stage found that the teaching materials used at SDN Sukatani VI were in the form of LKS purchased from publishing services and not made by the teachers themselves due to time constraints. The practice questions given have not referred to training higher-order thinking skills, and teachers have not used them due to time constraints, lack of socialization in writing HOTS questions, and using the same question model. Teachers tend not to use it. Because the learning process applied in class IV still tends to be teacher-centered, and students are immediately given formulas, the thinking skills they acquire are only remembering (C1), understanding (C2), and applying (C3).
b. Analysis of students based on observations that have been made, it is found that grade IV students at SDN Sukatani VI have characteristics that are easily bored with what is delivered by the teacher because teaching and learning activities are teacher-centered. In addition, students are also less active in finding various information related to the material they learn.
c. The task analysis that researchers will carry out is to ask students to work on worksheets and question sheets related to everyday problems contained in LKPD to determine whether students can develop higher thinking skills.
d. Concept analysis aims to find out what the concepts of Realistic Mathematic Education-based Learner Worksheets (LKPD) are to develop students' higher-order thinking skills that researchers

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will develop. This is done to identify the main concepts that will be developed in RME-based LKPD teaching materials. (Muqdamien et al., 2021).. Most schools only provide LKS teaching materials that are very commonly used, such as summarising all material with practice questions without knowing whether the LKS has invited students to think at a higher level or not, as well as SDN Sukatani VI. This causes students to find still it difficult to solve problems because what is available in the worksheet is limited. Therefore, the researcher developed an RME-based mathematics Learner Worksheet (LKPD) to develop higher-order thinking skills of grade IV students in SD / MI.

2. Design

The product that researchers developed in this phase was an RME-based mathematics LKPD on the perimeter of flat shapes (square, rectangle, and triangle) designed in accordance with predetermined steps. The following is an overview of the RME-based mathematics LKPD.

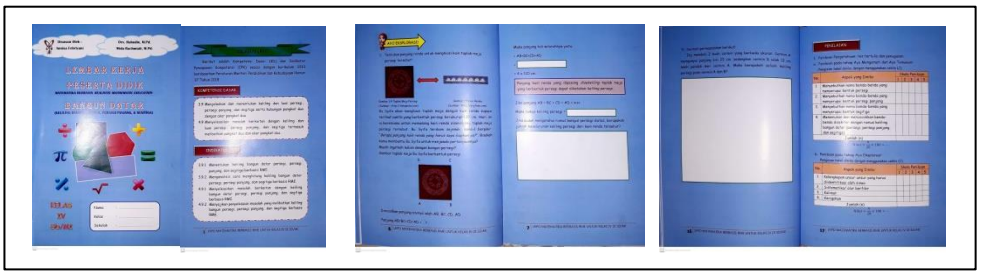

Figure 1. Product of RME-Based Mathematics LKPD

3. Develop

At this stage, it aims to produce an RME-based mathematics LKPD product that has been validated and revised by mathematics education experts and teacher responses to test the feasibility of the developed product. At the same time, the development trial for students will test the effectiveness of RME-based mathematics LKPDs that researchers have provided in accordance with KD and indicators.

a. Mathematics education expert validators conducted by mathematics education expert lecturer Mr. Trian Pamungkas Alamsyah, M.Pd.

Table 1. Mathematics Education Expert Validation Data Table

No.	Criteria	Expert Test (PS)	Ideal Score (PM)
1.	Didactic Aspects	15	20
2.	Construction Aspects	30	35
3.	Technical Aspects	24	30
4.	Aspects of Content Appropriateness	9	10
5.	HOTS Aspect	12	15
6.	Aspects of RME	16	20
7.	Design Aspect	43	50
8.	Language Aspect	17	20
Total		166	200

$$Final\ Score = \frac{PS}{PM} \times 100\%$$

$$FS = \frac{166}{200} \times 100\% = 83\%$$

Considering the consequences of the information that has been obtained through the approval of mathematics education experts getting a final score of 83% ranked "Good" or "Valid", the LKPD can be tried immediately.

b. Mr Sulaiman Fahmi, S.Pd, conducted the teacher response questionnaire as the fourth-grade teacher at SDN Sukatani VI.

Table 2. Class IV Teacher Response Questionnaire Table

No.	Criteria	Expert Test (PS)	Ideal Score (PM)
1	Aspect of Interest	15	15
2	Aspects of Assistance	23	25
3	HOTS Aspect	10	10
	Total	48	50

$$Final\ Score = \frac{48}{50} \times 100\% = 96\%$$

Based on the validation of the questionnaire from the response of the fourth-grade teacher of SDN Sukatani VI, the final score of 96% is categorized as "Very Feasible" or "Very Good" for use.

c. Response questionnaire for class IV students, totaling 35 students

Table 3. Learner Response Questionnaire Table

No.	Student Name	Total Raw Score (PS)	Total Ideal Score (SM)
1.	Ahmad Faiz Muzaki	10	10
2.	Diki	8	10
3.	Riza	8	10
4.	M. Ahza Radinva	10	10
5.	Sinta Nurul Aulia	9	10
6.	Amora Keristiyanti Sitohong	9	10
7.	Kaisya Ramadhan	9	10
8.	Zareta Savella Cahyani	9	10
9.	Nurrofiah Qois	9	10
10.	Larisya Putri Dianti	9	10
11.	Velinda Safira	9	10
12.	Rafa Algafari	9	10
13.	Eka Islamiah Putri	9	10
14.	Fauzan DF	9	10
15.	Paiz Sugeng Riyadi	10	10
16.	Arvan	6	10
17.	Renada Editawardani	9	10
18.	Love Balqis Batnisya	8	10
19.	Arga Ramadhan	10	10
20.	Leandra	10	10
21.	Word	9	10
22.	Revano	9	10
23.	Fahro Nizam	9	10
24.	Aditya Kusnadi	9	10

25.	Iffa Fitri Widiyanti	9	10
26.	Alisha Nanda Kurniawati	9	10
27.	Qori Hilmiya Qinasih	9	10
28.	Yefta	9	10
29.	Mario	10	10
30.	Alfi	9	10
31.	Aulia Ramadhani	9	10
32.	Fatimah Azzahra	9	10
33.	Qoerunnada Saliya Surya	10	10
34.	Ghina Maulida Salma	9	10
35.	Olivia Delvina	9	10
Total		316	350
Average Score Category		90.28% (Very Good)	

$$Final\ Score = \frac{316}{350} \times 100\% = 90{,}28\%$$

Based on the data above, a final score of 90.28% was obtained for the average assessment of students' responses to the LKPD teaching materials that have been developed. The average assessment is in the "Very Good" category.

d. This development trial was carried out in class IV SDN Sukatani VI, which had 35 students. This activity is the final stage to determine the effectiveness of the LKPD developed by researchers using pretests and posttests.

1) Pretest

Table 4. Table of Development Product Trial Pretest Results

Number of Students	Total Pretest Score	Description	
		Pass	Not Passed
35 Students	1120	4	31
Average Value	$\frac{1120}{35} = 32$	Learning Completeness Score $\frac{4}{35} \times 100\% = 11{,}4\%$	

Based on the results of the *pretest* using essay before using the product development of RME-based mathematics LKPD, it can be seen that the score of students learning mathematics on the perimeter of flat shapes (square, rectangle, and triangle) obtained an average score of 32 (Very Poor). The percentage of student learning completeness is 11.4% (Not Good) with KKM applied at SDN Sukatani VI, which is 70 for mathematics subjects.

2) Posttest

Table 5. Table of Posttest Results of the Development Product Trial

Number of Students	Total Pretest Score	Description	
		Pass	Not Passed
35 Students	3100	4	31
Average Value	$\frac{3100}{35} = 88{,}5$	Learning Completeness Score $\frac{29}{35} \times 100\% = 82{,}8\%$	

Based on the posttest results above, the numerical scores of students who used RME-based number-related worksheets for the edge material of flat shapes (square, square, and triangle) had an average score of 88.5 (Generally very good) with 82.8% (Excellent), or an increase of 29 students out of 35 students who achieved scores above the KKM. This can show an

improvement compared to the pretest before using the RME-based mathematics LKPD, which showed the material that got an average score of 32 (Very Poor) with a score of 11.4% (Poor) or more than four students who achieved the KKM score so that it shows that the material that uses RME-based LKPD has developed by 71.4%.

3) Recapitulation of trial test results using the N-Gain test. At the N-Gain test stage, the cycle is to see the difference in scores between the pretest and posttest scores. This will pay attention to the development of HOTS thinking (analyzing, evaluating, and creating) in students after learning by using *RME-based* mathematics LKPD teaching materials.

Table 6. Table Recapitulation of Pretest and Posttest Results Using the N-Gain Test

Number of Students	Pretest	Posttest	N-Gain
35 students	1120	3100	28,95
Average	32	88,5	0,82

Judging from the results of the data examination using the N-Gain Test, with an average final score of 0.82 with each classification of student answers, I experienced an increase and improvement after becoming accustomed to using Realistic Mathematic Education-Based Mathematics teaching materials.

4. Disseminate

This disseminate stage aims to disseminate products that have been made and developed. In this study, only limited dissemination was carried out, namely by disseminating and promoting the final product of RME-based mathematics LKPD to develop higher-order thinking skills of grade IV students in SD / MI on a limited basis to teachers of SDN Sukatani VI. This dissemination was conducted through discussion, during which researchers conveyed several things related to the product using presentation media.

The findings of this study suggest that the use of RME-based LKPD can significantly improve students' higher-order thinking skills. This has important implications for educational practice as it indicates that incorporating realistic and contextual problems into mathematics worksheets can enhance students' engagement and understanding. Teachers should consider integrating RME principles into their teaching materials to foster better learning outcomes. Additionally, the positive responses from both teachers and students highlight the practicality and effectiveness of the developed LKPD, suggesting that similar approaches could be beneficial in other educational settings.

Despite the promising results, this study has several limitations. The sample size was limited to one school, which may affect the generalizability of the findings. Future research should involve a larger and more diverse sample to validate these results. Additionally, the study focused on a specific mathematical topic (perimeter of flat shapes), so further research could explore the application of RME-based LKPD in other areas of mathematics and different subjects. It would also be beneficial to conduct longitudinal studies to examine the long-term effects of using RME-based teaching materials on students' higher-order thinking skills and overall academic performance.

CONCLUSIONS AND SUGGESTIONS

The final results considering the development strategy of RME-based number-related worksheets using the 4D model consist of several phases, including characterization/definition (Define), planning (Design), creation/design (Develop), and dissemination (Disseminate). From the results, it is concluded that based on the procedure for developing RME-based mathematics, LKPDs using the 4D model consist of several stages, including defining (Define), designing (Design),

developing (Develop), and disseminating (Disseminate*)*. The quality of RME-based mathematics LKPD to develop higher-order thinking skills of grade IV students in SD / MI produced based on this research and development is reviewed in terms of validity and feasibility. The assessment of the quality of LKPD based on the validation of mathematics education experts received a score of 83% with the category "Valid" without revision. It may be tested, while the assessment of LKPD based on the validation of the fourth-grade teacher's response received a score of 96%, categorized as "Very Valid or Feasible" for use, and the response of students to the product developed received a score of 90.28% with the category "Very Good / Feasible".

The effectiveness assessment of the LKPD developed by being tested on students received a score of 82.8%, with the average student learning outcomes reaching 88.5, exceeding the KKM using pretest and posttest test instruments, which can be categorized as "Very Effective" for use. As a consequence of the pretest, the learning outcomes of 32 students at a rate of 11.4% or more than four students have reached the KKM. In the pretest results, the learning outcomes of 32 students, with a percentage of 11.4% or as many as four students, reached the KKM. In the posttest results, the average value of student learning outcomes is 88.5, with a percentage of 82.8% or as many as 29 out of 35 students having reached the KKM. Thus, the product development of RME-based mathematics LKPD is categorized as "Very Effective" to be used to develop higher-order thinking skills in grade IV students in SD / MI. Furthermore, the restatement of the pretest and posttest results using the N-Gain test with an average final score of 0.82 with each classification of student answers has increased and improved after being accustomed to using Realistic Mathematic Education-Based mathematics LKPD teaching materials.

For educational practitioners, it is recommended that RME-based LKPD be integrated into regular teaching practices to foster higher-order thinking skills. Teachers can start by incorporating realistic and contextual problems into their existing worksheets and gradually develop new RME-based worksheets tailored to their students' needs. Additionally, professional development workshops and training sessions on RME principles and the development of RME-based LKPD should be provided to equip teachers with the necessary skills and knowledge.

Other researchers are suggested to explore the implementation of RME-based LKPD in different subjects and educational levels. Research could be conducted to evaluate the effectiveness of these worksheets in secondary education or other subject areas such as science and social studies. Furthermore, longitudinal studies could provide valuable insights into the long-term impact of RME-based teaching materials on students' cognitive and academic development. Collaborations with educational institutions to conduct large-scale studies could also help in validating the generalizability of the findings.

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