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Realistic mathematics education: An approach to improve problem solving ability in primary school

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ABSTRACT

Mathematical problem solving was an crucial skill to be mastered by primary school student so that will help student to unravel their problems encountered in everyday life. By using the realistic mathematics approach, stundents learn mathematical concept based on reality or scope around students. This study aimed to develop an eligible learning materials and test the effectiveness of learning materials based on realistic mathematics education to enhance the problem solving skill of primary school students. This research and development study was conducted in Sawangan Subdistrict, Magelang Regency, Central Java, Indonesia. The testing subjects consisted of 12 students in the the preliminary field, there were 42 students in the main field, and 90 students in the operational field that divided into experiment dan control class. The data were collected by interviews, observation, and tests. The analyzing N-gain score and t-test with a significant level of 0.05 done to find out th effectiveness of the teaching materials. The developed of realistic mathematics eduation learning materials is feasible and effective in improving problem solving skill with significance value of 0.000 ($p \leq 0.05$). It can enhance the problem solving skills of 4th grade elementary school.

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1. INTRODUCTION

Mathematics is the basic science of the development of science which has an important position in all aspects of life. In learning mathematics, of course a student will encounter learning about the concept of counting and is expected to be able to apply it in daily life. By proposing real problems, students are gradually guided to understand concepts and solve mathematical problems [1]. Problem-solving skills in Indonesia are still in the low category, as indicated by a survey by the International Association for the Evaluation of Educational Achievement (IEA) which measures the development of mathematics and natural sciences of grade IV and VIII students in Trends in International Mathematics and Science Study (TIMSS) 2015 put Indonesia in 44th position out of 49 countries in the field of mathematics with an average score of 397 [2]. This result is under the international average score. It can be interpreted that the skills of Indonesian students in solving math problems that require the ability to research, reason, communicate effectively, and solve and interpret problems are still in the low category.

Problem solving is an crucial thing taught in mathematics, because it involves the coordination and composition of several previous skills, beliefs, attitudes, perceptions, knowledge, and achievements [3].

Furthermore, National Council of Teachers of Mathematics has shifted the focus of learning mathematics from content to problem solving skills. Problems in mathematics are interpreted as questions or situations related to real situations in everyday life that require appropriate mathematical methods and knowledge to solve them [1]. It is hoped that with problem solving learning in elementary schools, students can solve the problems they encounter in everyday life. As Ergen states that students who are able to master this problem solving skill are likely to find it easier to solve everyday problems easily [4]. There are three main components in solving a problem for children that must be done, namely understanding the problem, generating ideas, and preparing or determining action [5]. Students who are used to solving problems will improve their intellectual skills. Measurement of mathematics problem solving skills in elementary school students refers to the problem solving indicators put forward by Polya in Ersoy, namely: i) Understanding of the problem; ii) Devising of plan; iii) Carrying out of plan; and iv) Looking back [6].

To be able to teach students problem-solving skills, of course, learning mathematics requires the right teaching materials. Teaching materials are a crucial component in the continuity of the learning process. Learning materials can be characterized as data and information that are spoken to in an assortment of media and designs, and that help the accomplishment of learning results expected. The aims of using learning materials is to support and facilitate the learning and learning process [7]. This means that teaching materials should adapt to the needs of students in order to achieve learning objectives. The learning material component should contain the required learning material and be presented in an instructional manner by placing teaching materials as the main means of learning. The elements of teaching materials should contain material needed by students and can be used as facilities for educators in guiding students to be able to build knowledge through learning activities [8]. Learning materials are basic and critical devices are required for instructing and learning measure or a significant apparatus for teachers to facilitate learning productively and to enhance understudy learning accomplishment [9]. Seeing that elementary school age children are included in the concrete operational development stage, in which children experience the development of logical thinking skills. New cap skills include the use of reversible operations. Thought is not centralized, and problem solving is less constrained by egocentrism [10]. Therefore, the use of teaching materials in the learning process must really be considered in its selection.

The types of learning materials used in this research are textbooks, lesson plans, and student worksheets. Textbooks are a guide to help teachers decide what to say and provide at least one way to teach it [11]. In mathematics learning, textbooks are a complicated piece of what is associated with doing school mathematics; they give systems to what is educated, how it very well may be instructed, and the sequence for how it very well may be educated [12]. The good planning is an important aspect of effective teaching [13]. For this reason, every teacher needs to prepare a lesson plan scenario design before starting learning activities. Teacher must prepare well and have well-structured lessons, so that teachers carry out teacher-led, but student-centered mathematics lesson [14]. Mathematics is also inseparable from abstraction skill. In learning mathematics, students should have the skill to find solutions to problems independently [15]. Therefore, in learning mathematics students need guides that help students in learning activities that are usually formed in student worksheets. Using student activity sheets is very helpful in the mathematics learning process. The teacher in this case only encourages students to work on math activity sheets without giving specific instructions [16]. The best way to introduce new mathematical concept is present learning with structured problem solving activity that combine between school mathematics and real life with the mathematical practice of modeling in mathematics [17].

In connection with the characteristics of elementary school students who still need concrete situations in learning mathematics, one appropriate learning approach is a realistic mathematics approach. Realistic mathematics education is a way to deal with learning mathematics that stresses the weightiness of science dependent on the way of thinking of mathematics as a human activity spearheaded by Hans Freudenthal in the Netherlands during the 1970s [18]. Mathematics learning must be developed by students in a context that makes sense according to them. These activities are called mathematics [19]. According to De Lange in Lestari and Surya, the way toward developing mathematical ideas and thoughts beginning from real life is called 'Conceptual Mathematization'. Figure 1 shows the conceptual cycle of mathematics proposed by De Lange [20].

Based on Figure 1, it can be seen that the development of a mathematical concept in realistic mathematics learning begins with student exploration activities in real world conditions. Then the opportunity is given to students to be creative in developing their thinking. To find and identify a given problem, students perform mathematicalization and reflection based on real situations with their respective strategies. Continued at the abstraction and formalization stage, students gain knowledge to develop concepts. Furthermore, students are trained to solve more complex real problems. After that students can apply mathematical concepts to the real world in order to obtain concepts.

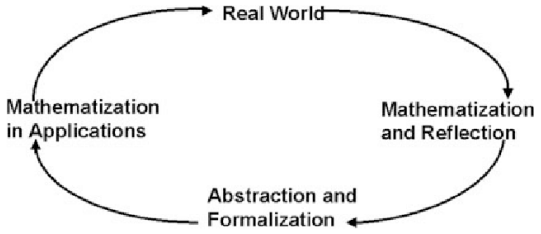

Figure 1. The conceptual mathematical cycle proposed by De Lange [20]

Realistic mathematics education five characteristics, include: i) The utilization of context: through the utilization of context, students are actively involved in exploring problems; ii) Use of models: the utilization of is a bridge from concrete knowledge and mathematics to formal level mathematical knowledge. By modeling, mathematics becomes more meaningful for learners [21]; iii) Utilization of student construction results: the results of the student's work and construction are then used as a basis for developing mathematical concepts; iv) Interactivity: interaction between students will become more meaningful by communicating work results and ideas between students; v) Linkage: Kraft-mathematical concepts are not introduced to the students separately , but associated with other mathematical concepts [18], [22]. The learning application with the RME approach also adheres to 4 principles [23] that is developed through the iceberg principle, where the stages are the real world, scheme formation, development knowledge, and formal abstract.

2. RESEARCH METHOD

This research was conducted to develop learning materials supported realistic mathematics education that are modified in terms of appearance and content. In terms of appearance, the teaching materials supported realistic mathematics education will be designed attractively through a combination of colors and illustrations. Meanwhile, in terms of teaching material content based on realistic mathematics education, it will present learning activities that are in accordance with the context of students' daily lives which are presented in student activity sheets where the development will certainly be adjusted to the characteristics and level of children's development so that it is easy to understand.

This study is a type of research and development (R&D) with reference to the research model of Borg and Gall that there are two main objectives in this research and development procedure, namely producing development products and testing the effectiveness of the product in achieving goals [24]. The subjects of this study were grade 4 elementary school students which included 12 students in the initial trial, 42 students in the field trial, and 90 students in the operational trial. In operational trials using a quasi-experimental research method with a non-equivalent control-group design [25], where 90 students were divided into one control class and two experimental classes. Data collection techniques used in this study were i) Interviews and observations to gather information related to needs in the field; ii) Questionnaires to determine student and teacher responses to products; iii) Scales for product assessment by media and material experts; and iv) Test to measure problem-solving skills. The feasibility of the teaching material product is known by analyzing the results of the assessment of media experts and material experts who calculated the average score on each indicator and then categorized it into a criterion. Then the average score was converted into four scales using the reference formula from Mansyur [26] the criteria are presented in Table 1.

Table 1. Guidelines for categorization of product feasibility assessment scores [26]

Score Interval	Score	Category
Ri + 1.5 Sdi < score ≤ maximum total score	A	Very feasible
Ri < score ≤ Ri + 1.5 Sdi	B	Feasible
Ri - 1.5 Sdi < score ≤ Ri	C	Less feasible
Total minimum score ≤ score ≤ Ri - 1.5 Sdi	D	Not feasible

R_i = ideal average = $\frac{1}{2}$ (maximum score + minimum score)

Sdi = ideal standar deviation = $\frac{1}{6}$ (maximum score - minimum score)

Product effectiveness data obtained from the problem-solving skill test analyzed from the pretest and posttest results, then calculated the gain value before and after the action. The standard gain calculation refers to the role of normalized gain (1).

$$g=\frac{\text{a score-b score}}{\text{max score-b score}} \quad (1)$$

(a score=posttest score, b=pretest score)

The results of the gain score were then interpreted into several effectiveness categories, including (g)≥0.7 which was categorized as high, 0.7≤(g)≥0.3 was categorized as moderate, and (g)<0.3 was categorized as low.

3. RESULTS AND DISCUSSION

Based on the research and development that has been carried out on grade 4 elementary school students in the Sawangan sub-district, the resulting teaching material products are feasible and have a positive effect in increasing problem-solving skills. Further, it will be discussed in the following explanation.

3.1. Feasibility of teaching materials based on realistic mathematics education

In the product development process, teaching materials based on realistic mathematics education go through a feasibility test before being tested for their effectiveness. Based on the feasibility test, this learning materials based on realistic mathematics education received an assessment from several experts, media experts and material experts. An assessment of the media aspects in learning materials based on realistic mathematics education was carried out by a media expert. Learning material products can be declared feasible if all aspects get a minimum score of B or the category "Feasible" with a score between 80 to 104. Table 2 is a summary of the results of the media expert's assessment.

Table 2. Results of product assesment by media experts

No	Indicator	Score	Score	Category
1.	Graphics	51	A	Very feasible
2.	Preliminary	21	A	Very feasible
3.	Contents	30	A	Very feasible
4.	Consistency	17	A	Very feasible
	Total	119	A	Very feasible

Based on Table 2, the results of the assessment learning materials based on realistic mathematics education by media experts scored 119 . The minimum score on the product feasibility assessment by media experts is 104, so with a score of 119 the product gets an A and is declared Very Feasible by the media expert. Furthermore, an assessment of the material aspects of learning materials based on realistic mathematics education is carried out by a material expert. Products assessed by material experts include textbooks, lesson plans, and student worksheets. Textbook products can be declared feasible if all aspects get a minimum score of B or in the "Feasible" category with a score ranged 92.5 to 120.25. Table 3 is a summary of the results of the textbook assessment from material experts.

Table 3. Results of textbook assesment by material experts

No	Indicator	Score	Score	Category
1.	Contents	41	B	Feasible
2.	RME approach components	16	B	Feasible
3.	Facilitate problem solving skills	13	B	Feasible
4.	Facilitate a confident character	11	B	Feasible
5.	Language and readability	18	B	Feasible
	Total	99	B	Feasible

Based on Table 3, the results of an assessment of textbooks based on realistic mathematics education by material experts scored 99. The minimum score on the textbook feasibility assessment by material experts is 92.5, so with a score of 99, the product gets a B value and is declared Feasible by the material expert. In the lesson plans product, it can be declared feasible if all aspects get a minimum score of B or the "Feasible" category with a score ranged 67.5 to 87.75. Table 4 reveals a summary of the results of lesson plans from material experts.

Table 4. Results of lesson plans by material experts

No	Indicator	Score	Score	Category
1.	Format	40	B	Feasible
2.	Contents	18	B	Feasible
3.	Principles of lesson plans development	21	B	Feasible
	Total	79	B	Feasible

Based on Table 4, the results of the assessment of the lesson plans based on realistic mathematics education by the material expert received a score of 79. The minimum score on the assessment of the feasibility of the lesson plans by the material expert was 67.5, so with the result of a score of 79, the product got a B value and was declared Feasible by the material expert. On the student worksheet product, it can be declared feasible if all aspects get a minimum score of B or the "Feasible" category with a score ranged 45 to 58.5. Table 5 reveals a summary of the results of student worksheet assessments from material experts.

Table 5. Student worksheets assesment results by material experts

No	Indicator	Score	Score	Category
1.	Material/Contents	23	B	Feasible
2.	Presentation	15	B	Feasible
3.	Language	12	B	Feasible
	Total	50	B	Feasible

Based on Table 5, the result of the student worksheets assessment based on realistic mathematics education by material experts gets a score of 50. The minimum score on the feasibility assessment of the student worksheets by the material expert is 45, so with a score of 50, the product gets a B score and is declared Feasible by the material expert. Thus, learning materials based on realistic mathematics education declared eligible by media specialists and subject matter experts to further be used in initial trials to make improvements in accordance with the advice and input by experts. In the initial trial the product was tried out to find out the teacher's response and student responses to get suggestions and input on product improvements so that it could be continued in field trials and operational trials. This study showed that teaching materials with applying realistic mathematics approach is recommended for learning mathematics. Realistic mathematics education takes students into the real world of daily life so that learning in math lessons is not separated from the student's daily life. Using the real world helps improve students' understanding of abstract mathematical concepts [27]. In line with that, Laurens [22] argues that learning mathematics is more effective if students can actively process and manipulate information. RME emphasized the use of learning support related to student abilities.

3.2. The effectiveness of realistic mathematics education-base teaching materials to improve problem solving skills

The operational trials were carried out after teaching materials based on realistic mathematics education went through several stages of revision. Operational trials conducted to work out the effectiveness teaching materials supported realistic mathematics education to enhance the problem solving grade IV Primary School. The operational trial is the last stage in testing the product developed, the research at this stage uses three classes, namely one control class and two experimental classes. The test of students 'problem solving skills is used to work out the effectiveness of learning materials supported realistic mathematics education that have been developed to reinforce students' problem solving skills.

The problem-solving skill test is administered twice for every class, the pretest is the learning before using teaching materials based on realistic mathematics education and posttest is the learning after using teaching materials based on realistic mathematics education. The effectiveness of teaching materials based on realistic mathematics education can be seen from the results of hypothesis testing on the pretest and posttest scores of students' problem solving skills. The pretest and posttest data were obtained from the results of the students' work in doing the problem solving skill test questions. The data summary and the pretest and posttest scores of the test results of problem-solving skills in the control and experimental classes can be seen in the Table 6.

Table 6. Summary data pretest and posttest score of problem solving skills

No	Class	Average Score		Gain	Criteria
		Pretest	Posttest		
1.	Control	45.75	62.79	0.31	Moderate
2.	Experiment 1	48.41	78.79	0.58	Moderate
3.	Experiment 2	47.64	79.92	0.61	Moderate

Based on Table 6, the average scores of the pretest result of the problem solving skills in the control class was 45.75 which carried out learning activities as usual using learning materials that were already available in schools. The results of the posttest score of problem solving skills were 62.79. The results of the pretest and posttest indicate that the problem-solving skills of students in the control class have increased with a gain of 0.31 in moderate criteria.

In the experimental group discovered that the average scores of the results of the pretest problem solving skills by 48.41 in the experimental class 1 and 47.64 in the experimental class 2. Furthermore, the treatment was carried out using teaching materials supported realistic mathematics education as learning materials used in learning activities, after which a posttest was carried out and obtained an average score of 78.79 in the experimental class 1 and 79.92 in the experimental class 2. The results of the pretest and posttest indicate that the problem solving skills of students in the experimental class has improve with a gain obtained of 0.58 in the moderate criteria in the experimental class 1 and the gain value of 0.61 in the moderate criteria in the experimental class 2. Thus, the gain in the two experimental classes is greater than the gain in the control class. Figure 2 shows a diagram of the comparison of the value of students' problem solving skills in the control class, experimental class 1 and experimental class.

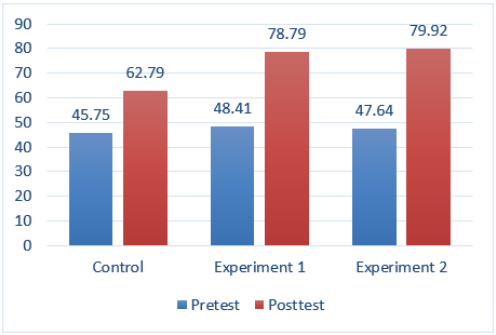

Figure 2. Comparison of problem solving skill results

Based on Figure 2, it is clear that the increase in problem-solving skills in the control class students is lower than the increase in the experimental class 1 and 2. The increase in the average score in the control class is 17.04 with a gain of 0.31, while in the experimental class 1 it occurs an increase in the average value of 30.38 with a gain of 0.58 and in the experimental class 2 there was an increase in the average of 32.28 with a gain of 0.61. These results indicate that the student's problem-solving skills in the experimental class has increased higher than the control class. In addition to the results of the N-gain problem-solving skill test, the data were also analyzed using SPSS 18 by performing an Independent t-test after the data was declared to be normally distributed and originating from a homogeneous population. The t-test was carried out to determine whether there was a difference in problem-solving skills between the control class and the experimental class.

The criteria for acceptance and rejection of Ho at a significance level of 0.05 is if the significance value is >0.05 then Ho is accepted, if the significance value <0.05 then Ho is rejected. Table 7 shows the results of the independent t-test for problem-solving skills.

Table 7. Independen t-test results of problem solving skills

No	Class	Data	Significance	Condition
1	Control Experiment 1	Posttest Posttest	0.000	There is a difference
2	Control Experiment 2	Posttest Posttest	0.000	There is a difference

Based on Table 7, the results of the independent t-test, the significance value of each <0.05, that is, both of them are 0.000. Thus, Ho is rejected and Ha is accepted, so it can be concluded that there is a difference in problem-solving skills between students who utilize teaching materials supported realistic mathematics education and students who do not utilize learning materials supported realistic mathematics education. Based on the analysis gain scores result and the t-test on opertional field testing, it can be stated that the problem solving skill of students in the experimental class has increased higher than the control class. Thus, it can be seen that teaching materials supported realistic mathematics education can be declared effective in increasing the problem solving skills students of grade 4 elementary school.

The results of this study show that teaching materials based on realistic mathematics education approach developed to offer a positive response and influence on student's learning mastery, especially on students' mathematical problem solving skill, which yield accordance with the results of the materials development research obtained by Harahap, Hasratuddin, and Simamora [28] Hasibuan, Saragih, and Amry [29]. In line with that, the results of the study conducted by Manurung, Siagian, and Minarni [30] by utilize the Realistic Mathematics Education approach students themselves find their knowledge and master the findings correctly, while the teacher's role is to guide students by giving direction and students are encouraged to think for themselves so they can find general principles based on directives/questions the questions given by the teacher and how far the students are guided depends on their skills and the material being studied. Students will be helped in understanding concepts and using these concepts in solving mathematical problems by applying realistic mathematics education approach [27]. Therefore, learning should be related to how students participate in the lessons and the organization of knowledge.

4. CONCLUSION

The study found that the teaching materials supported realistic mathematics education are used as a feasible and effective learning material to improve students' problem solving skills grade 4 elementary school. Hopefully, it is useful to improve the problem solving skills of 4th grade elementary school.

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