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Development of Learning Materials Based on Realistic Mathematics Education Approach to Improve Students' Mathematical Problem Solving Ability and Self-Efficacy

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ABSTRACT

This study aims to analyze the effectiveness of learning materials based on realistic mathematics education approach, as well as improving mathematical problem solving ability and student self-efficacy. Learning materials that developed were lesson plan, student book, student worksheet, mathematical problem solving ability test and self-efficacy questionnaire. This research is a development research by using the development model of Thiagarajan et al. (1974). Learning materials that have met valid criteria according to experts, were tested in class VII of SMP Negeri 17 Medan. The results showed that learning materials based on realistic mathematics education approach met the effective criteria and can improved mathematical problem solving ability and student self-efficacy. Based on the results of the study, it was suggested that mathematics teachers make an effort mathematical learning using learning materials based on realistic mathematics education approach.

Keywords: development of learning materials, mathematical problem solving ability, realistic mathematics education approach, student self-efficacy

INTRODUCTION

Education is a very important thing and cannot be separated from life. The importance of education, so that it becomes a benchmark for the progress of a nation. A developed nation is a nation that has quality human resources, both in terms of spirituality, intelligence and skill. One of the things that can be done to achieve this goal is continuous renewal in the field of education, especially mathematics subjects (Hasibuan et al., 2018).

The vision of Indonesian mathematics education states that mathematics education is devoted to understanding mathematical concepts and ideas which are then applied in routine and non-routine problem solving through reasoning, communication, and connection development inside mathematics and outside mathematics itself (Saragih et al., 2017). Students are expected to be able to use mathematics and mathematical thinking in daily life and to study many kind of sciences which stress to logical arrangement and student's character building and also ability to apply mathematics (Saragih and Napitupulu, 2015). The results of the data analysis of PISA 2013 by Scherer and Beckmann (2014) stated that mathematical and scientific competencies significantly contribute to problem solving through out the country.

Phonapichat et al. (2014) stated that the main purpose of teaching mathematics is to enable students to solve problems in daily life. The mathematical problem solving ability itself is not only a goal in mathematics learning, but also something that is very meaningful in daily life (Pinter, 2012), and in the world of work;

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being a problem-solver can provide benefits (NCTM, 2000). Therefore learning should be developed to educate students to be able to realize and solve the problems that they face (Balım, 2009).

Even though mathematics is a very important subject in formal education and is closely related to human life, mathematics is not a subject of interest to students and mathematical problem solving ability of Indonesian students are still low (Nidya et al., 2015; Yerizon et al., 2018). Laurens et al. (2018) in his study reported that many students feel afraid and face difficulties in learning mathematics. Generally, mathematical problems are made so complex that it is difficult for students to solve them. The same matter, the low mathematical problem solving ability of students, also reported Surya et al. (2017) when making preliminary study stated that mathematics was a subject that was not in demand by most students. One question that the researcher gave to measure students' mathematical problem solving ability, obtained similar information; problem solving ability is very low. These reports show that the achievement of Indonesia's mathematical education vision is still far from expectations. The problem solving ability, as one aspect of the higher order thinking ability, is a very important ability. The low mathematical problem solving ability is an crucial problem to solved.

In mathematics learning, students' mental condition is an important aspect. The student's belief system (about itself about mathematics, about problem solving) determines student success in solving problems (Schoenfeld, 2013). Student self-efficacy, which is the student's confidence in his ability, influences students' mathematical problem solving ability. Students' mathematical self-efficacy is the students' belief in their level, generality, and strength of these students in various activities and contexts in learning mathematics (Bandura, 1994; Zimmerman, 2000). Self-efficacy belief influences life choices, motivation levels, function quality, resistance to difficulties and vulnerability to stress and depression (Bandura, 1994). Many researches on student self-efficacy have been carried out and the study results that self-efficacy is closely related to mathematics learning achievement (Ayotola and Adedeji, 2009; Liu and Koirala, 2009; Motlagh et al., 2011). Skaalvik et al. (2015) stated that student motivation was strongly predicted by self-efficacy. So, the student's self-efficacy should be taken seriously by the teacher.

In reality students' self-efficacy is still low. In a study conducted by Azwar et al. (2017), according to an interview with a teacher at SMA Negeri 1 Peureulak, showing that secondary school mathematics teachers rarely pay proportional attention to improving student self-efficacy. In line with these findings, Sukoco and Mahmudi (2016) stated that the majority of XI Science students at SMAN 1 Jetis Bantul were reluctant to answer and report their work ahead when the teacher asked them because the students felt that they could not provide the right explanation. This finding is based on interviews conducted by researchers with students. Teachers must find ways to improve students' mathematical learning ability and must emphasize self-efficacy by designing appropriate learning (Ayotola and Adedeji, 2009).

According to Susanti (2012), in general the approach of realistic mathematics education is an orientation approach towards realistic student understanding aimed at developing practical, logical, critical and honest mindsets that are oriented towards understanding mathematical concepts in problem solving. RME was first introduced and developed in the Netherlands in 1970 by the Freudhenthal Institute. Based on Hans Freudenthal's thinking, mathematics is considered a human activity and must be associated with reality (Hadi, 2005). In addition, Freudenthal believes that students should not be considered passive recipients of ready-made mathematics. According to him education must direct students to rediscover mathematics in their own way (Hadi, 2017).

The realistic mathematics education approach provides an opportunity for students to rediscover mathematical ideas and concepts with adult guidance through exploring various situations and real world problems. The process of developing mathematical concepts and ideas starting from the real world by De Lange (1996) is called mathematical concepts and has a schematic model of the learning process. The three main principles in the realistic mathematical education approach, Gravemeijer (1994): guided discovery and progressive mathematics; didactic phenomenon; independent model development. In RME, learning starts from the contextual problem (real world) for students that emphasizes ability, discussion, and provides arguments so students can use mathematics to solve problems with more meaningful processes. The same was expressed by Arisetyawan et al. (2014) that the use of real experiences in students' daily activities will make mathematics learning more meaningful and successful. Therefore, it is expected that teachers can design existing learning with the environment to achieve the goals set (Sapta et al., 2018).

Learning materials are essential and significant tools needed in teaching and learning activities in schools to improve teacher efficiency and improve student learning achievement (Nesari and Heidari, 2014; Olayanki,

2016). Learning materials are a number of materials, tools, media, instructions, and guidelines that students and teachers will use to conduct learning activities (Nasution and Sinaga, 2017; Trianto, 2013).

To carry out mathematics learning with a realistic mathematics education approach, learning materials are needed that are in accordance with the approach. Therefore, it is necessary to develop a qualified materials of realistic mathematical education approach. In this study, the topic of materials designed was a quadrilateral topic. Furthermore, the learning materials that developed were: Lesson Plan (LP), Student Book (SB), Student Worksheet (SW), Mathematical Problem Solving Ability Test (MPSAT) and Self-Efficacy Questionnaire (SEQ).

METHOD

This research was development research (design research). This study used a model of development of Thiagarajan et al. (1974) which is also often referred to as 4-D, includes 4 stages namely define, design, develop and disseminate.

The research was conducted at SMP Negeri 17 Medan, which is one of the junior high schools in Medan Tembung Subdistrict, Medan City, Indonesia. The subjects in this study were class VII students at SMP Negeri 17 Medan 2018/2019 academic year, while the objects in this study were learning materials developed based on the realistic mathematics education approach to quadrilateral topic.

The instruments used in this study were tests and questionnaires. Tests are used to measure mathematical problem solving ability and questionnaires are used to capture responses. Next, to see the effectiveness of the learning materials, which is seen from: (1) Classical learning completeness of students at least 85% of students who get a mathematical problem solving ability test have obtained a minimum score of 70; (2) Achievement of learning objectives for each item in the test of mathematical problem solving ability of at least 75%; (3) At least 80% of students respond positively to the components of the learning materials developed; and (4) The learning time used does not exceed the usual learning time (Hasratuddin, 2018).

To analyze the improvement of students' mathematical problem solving ability, data were obtained from the results of students' pre-test and post-test. Increasing students' mathematical problem solving ability can be obtained from normalized gain index data Hake (1999), as follows:

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

With the normalized gain index criteria (g) shown in **Table 1**.

Table 1. Normalized Gain Score Criteria

Gain Score	Category
$g > 0.7$	High
$0.3 < g \leq 0.7$	Medium
$g \leq 0.3$	Low

Furthermore, the achievement used in the student's self-efficacy instrument was taken based on the Likert scale. To determine student answer scores, researchers applied scoring guidelines for each statement, namely the score for each positive statement was 1 (strongly disagree), 2 (disagree), 3 (agree), and 4 (strongly agree) and vice versa for statement scores negative. Suwandi stated that to determine the range of self-efficacy assessments students used the following criteria (Prastini et al., 2014).

Table 2. Self-Efficacy Belief Level

Number	Conversion Value		Category
	Score	Value	
1	76-100	A	Very good
2	51-75	B	Good
3	26-50	C	Good enough
4	0-25	D	Not good

RESULT

The Description of Learning Materials Development Stage

In this development research, learning materials based on realistic mathematics education approach had met the quality of effective learning materials in trial II, or in other words, the final draft has been obtained in trial II. The results of the development learning materials using the Thiagarajan 4-D model are described as following:

Define

Based on observations on learning materials in SMP Negeri 17 Medan found some weaknesses in the learning materials used by teacher, because the teacher has not developed lesson plan according to student characteristics, subject matter in the book used by teacher and students does not present problem not routines such a as contextual problem related, and teacher do not use student worksheet as a support for learning activities. Furthermore, in the learning process the teacher still used a conventional education, and the teacher is also not accustomed to giving confidence to students trough motivational words so that students have self-efficacy in solving problem given.

Design

At this stage produced an initial draft of the lesson plans for 5 meetings, student book, student worksheet, mathematical problem solving ability test, and questionnaire self-efficacy student. All result at this design stage are called draft I.

Develop

At this stage validates draft I the experts and then conducts field trials. The aim is to see the weaknesses in draft I so that it can be revised and refined the learning materials developed. The results of expert validation in the form of assessment of content validity which shows that all learning materials meet valid criteria, with a total average value of validation lesson plans is 4,58, student book is 4,52, and student worksheet is 4,47. All mathematical problem solving ability test items and questionnaires self-efficacy student meet valid and reliable criteria. Instrument reliability is used to determine the test result. After calculation, the reliability of the mathematical problem solving ability test was 0,788 (high category) and the questionnaire self-efficacy was 0,883 (very high category).

After the learning materials developed have met the criteria for validity, then learning materials in the form draft II were tested in the research place, SMP Negeri 17 Medan, here in after refered to as trial I. Based on the result of trial I data analysis, it was found that the developing learning materials did not meet all effective criteria, so that improvements were made to produce learning materials that meet all the effective criteria set. Revisions were made based on the findings of the leraning materials weaknesses in the trial I, namely for lesson plans related to the allocation of learning time, as well as on student book and worksheet related to the material being taught. After the revision is complete, trial II is conducted to determine the effectiveness of the learning materials, as well as the improvement of mathematical problem solving ability and the attainment of self-efficacy student.

Disseminate

The development of learning materials reaches the final stage if it has obtained positive values from experts and through development tests. The learning materials are then packaged, distributed and determined for a wider scale. But in this study the disseminate stage was not carried out, so the fourth stage was not explained.

Result of Trial I

Based on the results of trial I data analysis, it was found that the learning materials that developed were not effective, because there were still some indicators of effectiveness that had not been achieved. The results of classical completeness in mathematical problem solving ability of students in the trial I, namely in the pretest was 36.11% while the posttest was 69.44%. This states that students have not meet the value of classical completeness. Furthermore, for the criteria achieving the learning objectives in the trial I have not yet reached each item.

The indicators of effectiveness that have been fulfilled in the trial I are the attainment of learning time, namely the learning time used is the same as ordinary learning time, besides that it is the response of students, namely students respond positively to learning materials based on realistic mathematics education approach with the average percentage of the total positive responses of students in the trial I was 87.52%.

Improvement of students' mathematical problem solving ability in the trial I was seen through N-gain from the results pretest and posttest of mathematical problem solving ability in the trial I. From the data obtained by students who received score N-gain in the range of $g > 0,7$ or experienced an increase in mathematical problem solving ability with the category "High" as many as 2 students, students who experienced an increase in mathematical problem solving ability with the category "Medium" or got a score N-gain of $0,3 < g \leq 0,7$ as many as 16 students and students who experienced an increase in mathematical problem solving abilitiy with the category "Low" or got a score N- gain of $g \leq 0,3$ as many as 18 students. While the average N-gain in the trial I obtained 0.313 in the medium category.

Based on the data obtained on the attainment of self-efficacy of students in the trial I most dominating is good category, which indicated that students in the trial I has good self-efficacy.

Result of Trial II

Based on the results of the trial II data analysis, it was found that the learning materials developed have been effective based on an indicators of the effectiveness of the learning materials that have been achieved. The results of classical completeness in mathematical problem solving abiliys of students in the trial II, namely in the pretest was 63.89% while the posttest was 88.89%. This states that students have meet the value of classical completeness. Furthermore, for the criteria achieving the learning objectives in the trial II, it was achieved for each item about mathematical problem solving ability.

Likewise, the learning time used is in accordance with the criteria for achieving learning time. Then the average percentage of the total positive responses of students in the trial II was 88.37%, so it can be concluded that students' responses to the components and learning activities was very positive.

Improvement of students' mathematical problem solving abilitiy from the data obtained in the trial II, there were 15 students who received scores N-gain in the range $g > 0,7$ or experienced an increase in mathematical problem solving ability with the category "High", 12 students experienced an increase in mathematical problems solving ability with the category "Medium" or got a score N-gain in the range $0,3 < g \leq 0,7$ and 9 students experience an increase in mathematical problem solving ability in the category "Low" or got a score N-gain of $g \leq 0,3$. The average gain in the trial II obtained 0.579 in the medium category.

Based on the data obtained on the achievement of self-efficacy students in the trial II most dominating is good and very good categories, which indicated that students in the trial II has a good self-efficacy.

DISCUSSION

Based on the results of the analysis posttest of the trial II, it was found that the students mathematical problem solving ability have met classical completeness criteria. This is because the material and problems that exist in the student book and worksheet are developed in accordance with the characteristics and environment of students so that students can use prior experience to solve mathematical problems that make the learning process more meaningful. This is in accordance with Ausubel's learning theory (Trianto, 2011), which states that learning is a process of linking new information or material with concepts that already exist in one's cognitive structure.

Student learning completeness is also influenced by learning education used in the learning process of realistic mathematics education approach that make students interested in learning and actively involved in the learning process. The same thing was stated by Safitri et al. (2017) that students are more active in the learning process by using RME than without using RME (traditional education). Furthermore, the results of the research of Wulandari et al. (2015) showed that learning materials based on realistic mathematics education approach developed included in the effective category in terms of students' classical learning completeness.

From the results of the analysis of the attainment of learning objectives in the trial II, it was found that the attainment of learning objectives had been achieved for each item. This is because learning is done using problems that are close to the life and environment of students so that it is affordable by students' imagination which makes it easier for students to look for possible solutions using the mathematical problem solving ability

they already have. This is relevant to Bruner's theory (Hudojo, 1988), because at the beginning of learning students do activities such as making observations in the environment or using knowledge from previous observations in the learning process (active phase). Furthermore, to help students understand contextual problems, in student book and student worksheet presented drawings relating to contextual problems (iconic stage), and in the contextual problem solving process students perform mathematical modeling in the form of mathematical symbols and equations and complete the contextual problem with the model found (symbolic stage).

Research related conducted by Widjaja and Heck (2003) state that pupils taught by realistic mathematics education approach showed progress in their performance between the pretest and the posttest. On the posttest they could give a greater number of correct answer. Furthermore, Fauzan et al. (2002) concluded that the pupils' attainments in the experimental class used a realistic mathematicas education approach significantly higher than the attainments of the pupils who had been taught using the traditional method. So it can be concluded that the attainment of this learning objectives shows that the use of learning materials developed meets the effectiveness criteria.

Based on the attainment of learning time conducted during the trial I and trial II, the length of time learning using learning materials based realistic mathematics education approach did not exceed the usual learning time during this time, namely five meetings or 10 x 40 minutes. Thus the learning time used is in accordance with the criteria of attainment of learning time, namely the attainment of the learning time used is the same as the usual learning time, so it can be concluded that the attainment of learning trial I and trial II have been achieved and meet the criteria of effectiveness.

As for the results of the data analysis of the trial I and the trial II, it was found that the average percentage of students responses in each trial was positive, meaning that the students felt helped and happy with the learning materials based realistic mathematics education approach. Student responses given to each trial have reached a predetermined criteria category of 80%. This shows that the learning materials based on realistic mathematics education approach developed have met the effective criteria in terms of student responses. This is also supported by the results of research conducted by Maulydia et al. (2017) that students respond to the teaching material that has developed through RME is positive because more that 80% students are interested to follow the teaching learning process by using the teaching material that has been developed.

Based on the results of the improvement in students 'mathematical problem solving ability in the trial I and trial II, it showed that there was an increase in students' mathematical problem solving ability of 33,33% in the trial I and occurred and increase of 25,00% in the trial II. Meanwhile, the increase in the results of the posttest trial I and trial II was 19,45%. This shows an increase in students' mathematical problem solving ability after using learning materials based on realistic mathematics education approach. The results of this study were in accordance with the results of the materials development research obtained by Harahap et al. (2018) which gaves results that learning materials based on realistic mathematics education approach developed to give a positive response and influence on student's learning mastery, especially on students' mathematical problem solving ability. Mathematical problem solving ability of students has increase. The results of the study conducted by Zakaria et al. (2017) when applying realistic mathematics education approach, and the result showed significant differences between the realistic mathematics education approach and the traditional approach in terms of achievement. The realistic mathematics education approach encourage students to participate actively in the teaching and learning of mathematics. Thus, realistic mathematics education approach is an appropriate methods to improve the quality of teaching and learning process.

Based on the result of questionnaire data analysis self-efficacy in trial I and trial II showed the attainment of self-efficacy good student. This is because mathematics learning with the use of learning materials based on realistic mathematics education approach presents meaningful learning with contextual problem that are closer to the student environment so as to make student actively interact between students and students or students with the teacher using prior experience and knowledge taht students have. This characteristic is relevant to Vygotsky's theory (Ansari, 2012) because this theory states that children's intellectual development is influenced by social factors. The social environment and learning naturally affect children's development in increasing complexity and cognitive functioning. In conecction with self-efficacy and mathematics learning attainment, Ayotola and Adedeji (2009) stated that there is a strong positive relationship between mathematics self-efficacy and attainment in mathematics. Futhermore, Liu and Koirala (2009) also stated the same thing that there is a positive relationship between self-efficacy and mathematical attainment. This shows that the realistic mathematics education is significantly better in improving self-efficacy student.

CONCLUSION

Based on the results of analysis and discussion in this study, it can be concluded that learning materials based on realistic mathematics education approach have met the effectiveness criteria, and mathematical problem solving ability and student self-efficacy have increased after using learning materials based on realistic mathematics education approach. This research shows that learning materials based on realistic mathematics education approach are important things to consider in an effort to maximize student mathematics learning achievement. Thus, it is expected that mathematics teachers seek mathematical learning using learning materials based on realistic mathematics education approach.

Disclosure statement

No potential conflict of interest was reported by the authors.

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