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Developing Learning Materials Based on PBL to Improve Mathematical Critical Thinking Skills and Self Efficacy of JHS Students at Besitang Small Town

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Abstract
This research is a research development of teaching materials based on Problem-based Learning (PBL) to improve mathematical critical thinking skills (MCTS) and self-efficacy of 8th-grade students. The teaching materials were designed so that they meet the valid, practical, and effective criteria. This research was conducted at junior high school (JHS) (SMPN 1) located in the small town of Besitang, Indonesia. The subject of the research is 34 students. The first step of this study is to analyze the level of validity, practicality, and effectiveness of problem-based teaching materials in improving students' mathematical critical thinking skills and self-efficacy. The findings of this study are: (1) PBL-based teaching materials have fulfilled valid, practical, and effective criteria in improving students' mathematical critical thinking skills and self-efficacy, (2) Improving mathematical critical thinking skills obtaining an N-gain score of 0.45, meaning that the increase is included in the category of "medium", (3) Improvement of students' self-efficacy is also included in the category of 'medium'. Thus, this research has produced problem-based teaching materials that are useful for schools in small towns, where its teachers still need to be convinced to implement teaching material innovations that can improve the capabilities of their students in solving mathematical problems and increasing self-efficacy.
Keywords: problem-based learning model, mathematical critical thinking skills, self-efficacy, mathematics teaching materials
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1. Introduction

To improve the quality of mathematics learning, teachers' efforts are needed to improve and develop learning models or approaches (Bell, 2011) along with interactions between students and teachers. Furthermore, teaching materials used by teachers must also be in accordance with the needs of students and the applicable curriculum. According to Dick & Carey (2009) "Teaching material is any form of material or material arranged systematically that is used to help the teacher or instructor in carrying out teaching and learning activities so as to achieve an environment or atmosphere that allows students to learn. The teacher must have teaching materials that are in accordance with the curriculum, target characteristics, and the demands of solving learning problems. Through these teaching materials, students can learn things that are needed in an effort to achieve learning goals. For this reason, the determination of teaching materials must be in accordance with the objectives to be achieved, whether in the form of knowledge, skills, attitudes, or other experiences.

But the reality on the ground shows that teachers have difficulty in designing and implementing mathematics teaching materials. That is due to changes in the 2013 curriculum in education in Indonesia. Therefore, Sihombing's research (2017) found that the preparation of teaching materials currently conducted by teachers is only for completeness of school administration, not to help the learning process in the classroom.

The teaching materials made by the teacher also do not meet the valid, practical, and effective criteria which result in the desired learning objectives not being achieved properly. The teacher and student handbooks of mathematics only contain routine questions, far from the questions that lead students to critical thinking skills. Student worksheets (LKS) are very dense but do not contain questions that require students to be critical and creative in completing them. Student responses to learning in class are also negative which causes students to be passive in learning, unskilled in solving math problems given; student mathematics learning outcomes are not satisfactory.

According to Nieveen (2007), there are three criteria that must be met in the development of teaching materials, namely: (1) validity, (2) practically, and (3) effectiveness. That is, teaching materials developed are said to be of high quality if they meet all three aspects (criteria). The validity of teaching materials, content validation, constructs, and language, are obtained through assessments given by experts and colleagues. The practicality of teaching material is assessed by the teacher who implements the teaching material in class. Teaching materials are said to be practical if the teacher states that teaching materials can be applied in class as planned and easily understood by students. Effectiveness can be seen from the results of authentic assessments which include assessments of the learning process and learning outcomes.

Originally, the 2013 curriculum changes made in Indonesia, especially in mathematics, aimed at changing

the learning process of students who were 'told' to students 'who sought out', combined with the assessment process from 'output based' to 'process-based and output ', and balancing soft skills and hard skills. One of the hard skills required in the 2013 curriculum and 21st-century competencies that students must construct is mathematical critical thinking skills.

The development of students' abilities in critical thinking is one of the focuses on learning mathematics. But in reality, learning mathematics in the classroom so far has not paid enough attention to the development of mathematical critical thinking skills so that the ability of students in this case case is not enough (still low). The low ability of students' mathematical critical thinking is thought to be due to learning in the classroom where the teacher dominates the learning process (activity), students are rarely given the opportunity to think critically. Math problems given by teachers are more questions that are routine so they do not train students' reasoning abilities to think critically. The teaching material provided by the teacher also does not encourage students to think critically.

In addition to students' mathematical critical thinking abilities, there is another aspect that is affective which is as important as mathematical critical thinking skills, namely self-efficacy. The demand for the development of self-efficacy is written in Indonesian curriculum, K-13, which consists of the following aspects: an attitude of appreciating the usefulness of mathematics in life, namely having curiosity, attention, interest in mathematics, as well as tenacity and confidence in problem-solving. The dimensions that must be considered from self-efficacy include dimensions of level, strength, and generality (Bandura, 1999).

One reliable learning model (approach) to overcome low mathematical thinking ability is problem-based learning (PBL) (Arends, 2004). According to Mareesh (2013), PBL is a learning model that is able to present students' authentic and meaningful problems that can make it easy for students to conduct investigations and inquiry. Still, according to Maresh, PBL is effectively used to teach mathematics, PBL also involves students in an active, collaborative, student-centered learning process. Based on the explanation above, then as an effort to overcome the problem of low mathematical critical thinking ability and self-efficacy of students, the researchers conducted research entitled " **Developing Learning Materials based on PBL to Improve Mathematical Critical Thinking Skills and Self Efficacy of JHS Students at Besitang Small Town** ".

Research Methods

The research methods consist of research design, subject of the research, data collection techniques, validity and reliability of the data, and data analysis.

Research Design

This type of research is Development Research. The development of teaching materials in this study refers to the procedure of the development model of Dick & Carey (2009). The development of instructional materials is designed based on problem-based learning models (PBL), including Student Books (BS), Student Activity Sheets (LKS), and a set of tests of mathematical critical thinking skills, and self- efficacy questionnaires.

Subject of The Research

The subjects in this study were students of class VIII-1 and VIII-2 of SMP Negeri 1 Besitang in the academic year 2019/2020, each consisting of 34 students.

Stage of The Research

The stages of the research include the defining stage, the development stage, the implementation. At the defining stage an analysis of students and teachers is conducted, analysis of teaching materials used by the teacher, as well as analysis of the school and school policies related to learning used by the teacher in the classroom; the development phase is the design phase of teaching materials to obtain teaching materials that are valid; The implementation phase consists of activities that implement valid teaching materials to obtain teaching materials that are effective and practical. Teaching material is said to be effective and practical if the teaching material can improve students' mathematical thinking abilities and self-efficacy; said to be practical if the teacher and students do not experience difficulties in using these teaching materials.

Data Collection Technique

The tool used to collect students' mathematical critical thinking skills (MCTS) is a mathematical critical thinking ability test. This test is used to obtain information about student mastery in circle topics. The test is given after all PBL-based learning activities are completed. Student self-fficacy data obtained through the self-efficacy questionnaire. This questionnaire was developed consisting of statement items in accordance with aspects of self-efficacy.

Validity and Reliability

Validity is a characteristic that must be possessed by tests of mathematical critical thinking skills and self-efficacy questionnaires, as well as completeness of teaching materials such as lesson plans (RPP), (b) Student Activity Sheets (LKS), and (c) student books (BS). This validation sheet contains the assessed components including format, language, illustrations, and content. Meanwhile, reliability is a criterion that must be met by the mathematical critical thinking ability test instrument. The reliability of the research instrument was obtained through the Cronbach alpha test.

Data Analysis

The data analysis technique used in this research is descriptive analysis. The data obtained were analyzed and directed to answer the question of whether the learning tools with problem-based learning models that were developed met valid, effective, and practical criteria for developing critical thinking skills and self-efficacy of junior high school students. Data on increasing mathematical critical thinking ability is determined based on the normalized gain index from Hake (2002), while the classification of the gain index refers to Meltzer's opinion (2002). Student self-efficacy data were analyzed based on the grouping of students' self-efficacy scores in the low, medium, and high categories.

Result and Discussion

The teaching material developed in this study is PBL based with the aim to improve the mathematical critical thinking skills and self-efficacy of junior high school students located in the small town of Besitang based on the modified material development model of Dick & Carey (2009).

This research produces PBL-based teaching materials that are valid, practical, and effective in improving students' mathematical critical thinking skills and self-efficacy. In addition, this study can also improve students' mathematical critical thinking skills and self-efficacy. These teaching materials include Lesson Plans (LP), Student Books (BS), Student Activity Sheets (LKS), tests of mathematical critical thinking skills, and student self-efficacy questionnaires.

Result

This research produces data related to the development of teaching materials, data about mathematical critical thinking skills, and data about students' self-efficacy.

a. Data on Teaching Materials

The problem-based teaching material developed in this study was designed to meet valid, practical, and effective criteria in improving mathematical critical thinking abilities and self-efficacy of students at SMPN 1 Besitang. Based on the results of this study the following data were obtained:

Table 1. Score of Learning Materials

Component of Learning Materials				Total Average	Category
LP	TB	SB	MCTS Test		
3.75	3.88	3.63	3.81	3.685	High

Note:
LP = Lesson Plan
TB = Mathematics book for the teacher
SB = Student book for the students
MCTS test = Mathematical Crititical Thinking Skills Essay Test

Based on Table 1, it can be said that the teaching materials developed in this study have included valid characteristics because the average score given by the validator is quite high, that is 3.685 on a scale of 5. The validator also states that the teaching material can be implemented after the developer revises those parts of teaching material that is considered validators need a little revision. Revisions have been made and returned to the validators. Thus, teaching materials have been categorized as having a good level of practicality.

b. Data on Mathematical Critical Thinking Data

Data posttest of students' mathematical critical thinking skills (MCTS) presented in Table 2 below.

Table 2. Data Improvement of Students' Mathematical Critically Thinking Ability

	Tes I	Tes II	Differnce
The Highest score	91.67	93.75	2.08
Average	73.52	80.08	6.56
The Lowest Value	37.5	52.08	14.58

From Table 2, it shows that the average of mathematical critical thinking ability of students in the posttest I result is 73.52. And the average mathematical critical thinking ability of students on the posttest II results is 80.08. This shows that an increase in the average mathematical critical thinking ability of students from the trial I to trial II was 6.56 or 6.56%.

c. Data on Self-Efficacy

Based on the results of the trial I and trial II obtained the results of student self-efficacy questionnaire. This questionnaire was given at the end of a PBL-based learning program. Data obtained from the results of the Self Efficacy questionnaire from the experiment I and experiment II were analyzed by comparing the average scores of students' self-efficacy from the experiment I and experiment II. The description of Self Efficacy is shown in Table 3 below.

Table 3. Self-efficacy Questionnaire Data

Dimention	Tes I	Tes II	Difference
Level	3.20	3.27	0.07
Strength	3.37	3.41	0.04
Generality	3.12	3.28	0.16
Average	3.21	3.32	0.11

Table 3 shows that the average score of students 'mathematical self-efficacy in try I was 77.17 while the average score of students' mathematical self-efficacy in try II was 79.76. Based on these data overall student self-efficacy in trial II is better than in trial I. This is in line with research conducted by Manurung, Siagian, & Minarni (2020) with student self-efficacy increasing between Trial 1 and Trial 2.

d. N-Gain Results on Mathematical Critical Thinking Skills

The student's N-Gain results if reviewed based on the average value of the pretest and posttest mathematical critical thinking skills are presented in table 4 below.

Tabel 4. N-Gain Results on Mathematical Critical Thinking Skills

Range	Boost Category	Tes I		Tes II	
		Total Students	Percentage	Total Students	Percentage
$N \geq 0,7$	High	1	2,94%	5	14,70%
$0,3 \leq N < 0,7$	Medium	22	64,70%	22	64,70%
$N < 0,3$	Low	11	32,35%	7	20,58%

From table 4, showing the results of the N-Gain calculation, it was found that the increase in students' mathematical critical thinking skills in trial I was 0.42 or in the category of "Medium". While in trial II, it was 0.45 or in the category "Medium". This shows that an increase in the average mathematical critical thinking skills of students from trial I to trial II.

Discussion

This section will begin with a description of the teaching materials developed and the achievement of valid, practical, and effective teaching material criteria. The discussion will continue with the problem of increasing mathematical critical thinking skills. Finally, there is a discussion about the achievement of students' self-efficacy after the implementation of teaching materials that have met the valid, practical, and effective criteria.

a. Description of Teaching Materials based on PBL

Based on the data in Table 1 it can be concluded that the teaching materials developed in this study have fulfilled valid and practical criteria. This is based on data that each component of teaching materials which include lesson plans, teacher books, student books, worksheets, and instrument tests have obtained an average score of validity level 3. Which is included in the valid category. The validator also in a closed questionnaire has stated that this teaching material can be implemented with a little revision. This shows that this teaching material has fulfilled some practical characteristics. Data on the implementation of learning by teachers in the classroom in limited trials complete these practical criteria.

Fulfillment of the effectiveness criteria of teaching materials in this study includes 2 indicators, namely the achievement of student learning completeness and student response towards teaching materials. Mastery learning means that students have achieved a minimum mathematical critical thinking ability score that is the target score in this study, which is a score of 65 on a scale of 100. This is in line with the opinion of Nieeven (2007) which states that effectiveness refers to the achievement of student learning outcomes following the goals set by the developer of teaching materials. The following data obtained from this study are: Increased mathematical critical thinking skills obtain an average N-gain of 0.45. The score indicates that the increase in CMTS is in the "moderate" category. Data related to self-efficacy in Table 3 shows that the average of each student's self-efficacy items has increased by 0.11 on a scale of 4 or about 11%.

Based on all these data it can be said that the problem-based teaching material developed in this study has reached valid, practical, and effective criteria in improving mathematical critical thinking skills and self-efficacy of Besitang Middle School students so that it can be applied more extensively in other schools Besitang small town.

Increased mathematical critical thinking skills in this study occurred because learning has been carried out following the syntax of the implementation of teaching materials used; that is following the PBL syntax. Discussions related to increasing MCTS are discussed in section 4.2. Likewise, an increase in student self-efficacy will be described in section 4.3 after the discussion of MCTS.

b. The Improvement of Mathematical Critical Thinking Skills (MCTS)

As stated earlier, what is meant by the MCTS is the ability to think that is reasonable and reflective on someone to make a decision that is believed to be truthful, logical, has credibility, adapts to the overall condition, is relevant to old ideas, finds new ideas as an alternative and sensitive to other sciences.

CMTS has increased from the trial I to trial II because in trial II an improvement was made in the quality of the weaknesses found in trial I. The results of this study support the results of research conducted by Siagian, Simanjuntak, and Samosir (2017) which obtained results that mathematics learning tools developed using PBL can improve students' mathematical critical thinking skills. This study is also in line with the results of research conducted by Yanti and Rully (2017) which concludes that the mathematical critical thinking ability (CMTS) of students taught using PBL teaching materials is higher than the CMTS of students taught using the guided inquiry approach.

This increase in CMTS is possible because, in classes that implement the PBL approach, students are continuously trained to solve good problems according to the characteristics of the problems suggested in PBL (Arends, 2008), ie problems that can make students able to achieve high order thinking skills. When students are accustomed to high-level mathematical thinking, they can be expected to be able to think critically. Therefore, teachers should familiarize students to think deeply, think carefully, and critically by giving them good problems, namely problems that are interesting, challenging, require several steps to obtain solutions, and require collaboration with other students (cooperative and collaborative).

c. Improvement of Mathematical Self-Efficacy

Bandura (1992) states that students' mathematical self-efficacy refers to a person's belief in their ability to organize and implement a series of actions needed to manage prospective situations. In general, this study found that students in trial II were more confident and diligent in doing math tasks than students in trial I. Data obtained from this study (Table 3) showed that students' self-efficacy had increased.

The highest increase occurred in the generality dimension which means students have experienced an increase in the generality aspect, namely aspects related to feeling confident about their abilities, students can assess their confidence in solving mathematical problems given in various materials or in certain materials only; this finding in line with Manurung, Siagian, & Minarni (2020) that stated whether or not someone can solve mathematical problems in a particular material or a variety of materials reveals a general picture of the student's self-efficacy.

The improvement of self-efficacy in this study can occur because throughout mathematics learning takes place, students unwittingly have honed their ability to plant the aspects of self-efficacy that were conceived by Bandura (1999), namely aspects of belief to be able to solve various problems, the ability to gain knowledge and doing math skills, self-discipline, and aspects of motivation and hard work. The level of self-efficacy has been measured based on Bandura's self-efficacy dimensions, namely the level, strength, and generality dimensions that are appropriate for junior high school students (see Table 3).

Throughout the learning process, the teacher has implemented learning using PBL-based teaching materials with an emphasis on guide students in setting goals, especially in making short-term goals after they make long-term goals, give rewards for student performance, combine training strategies with an emphasis on objectives and provide feedback to students about learning outcomes. The teacher provides support to students (positive support can come from the teacher such as the statement "you can do this", and others). Along with learning activity, the teacher also convinces that students are not too worried because it will reduce student self-efficacy.

The teacher also provides students with positive models such as peers and adults. Certain characteristics of the model can increase students' self-efficacy. Modeling is effective for increasing self-efficacy especially when students observe the success of their peers who have the same abilities as them. All of these activities are based on the notion of Bandura as written in Manurung, Siagian, & Minarni (2020).

Conclusion

Based on the results of data analysis and discussion, the researcher concludes that the teaching materials designed based on problem-based learning (PBL) in this study have met valid criteria. The implementing teacher stated that this teaching material was not difficult to use and in accordance with the time provided for mathematics lessons. It means the teaching materials have met the practical criteria in improving mathematical critical thinking skills and self-efficacy of middle school students at SMPN 1 Besitang. Because of the teaching materials that could increase mathematical critical thinking ability and self-efficacy, as well as acquired positive responses from teachers and students, then the teaching materials have met effective criteria. The improvement of mathematical critical thinking has been achieved both classically and individually. Classical achievement means that more than 75% of students in the class have achieved a score of more than the minimum score, in this case, the MCTS test score 65 of the ideal score of 100. While individually achievement means that the MCTS test score obtained an adequate N-gain. In this study, an N-gain of 0.45 was obtained. The improvement of student self-efficacy is included in the moderate category. Thus, it can be said that PBL-based teaching materials developed in this research have met valid, practical, and effective criteria so that it can be used in other grades 8 junior high schools in small towns such as Besitang.

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