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Teaching Material Based on Metacognitive Strategies to Improve Student's Critical Thinking Ability

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***Abstract*—This research was a development research that aimed to produce teaching material based on metacognitive strategies which valid, practical, and effective to improve students' critical thinking skills. The subjects of this research were Year 8 students at one of Junior High School in Bandar Lampung Academic Year 2017/2018 with purposive sampling techniques. Teaching material based on metacognitive strategies developed by using Research and Development method which referred to the development model. Data analysis techniques to get data of critical thinking skills in this study was quantitative data based on the results of critical thinking ability tests using Mann Whitney U test to determine differences in average learning outcomes and normalized N-gain to determine the effectiveness of metacognitive-based teaching material before and after learning. The results of the preliminary study indicated the need for the development of teaching material based on metacognitive strategies. The results of the validation of teaching material indicated that teaching materials was in the valid or feasible category. The results of the trial materials showed that the teaching material was included in the practical category. The effectiveness test results show that learning using teaching material based on metacognitive strategies is more effective to improve students' critical thinking skills compared to learning without using teaching material based on metacognitive strategies.**

Keywords—critical thinking ability; teaching material; metacognitive strategies

I. INTRODUCTION

Mathematics has an important role in everyday human life. The National Research Council's report states that "Mathematics is the key to opportunity". Students who succeed in learning mathematics get a tool to open the door to a brilliant career, support in making the right decisions, and become supporting knowledge in preparing themselves to compete in the technology and economic fields [1]. Besides being useful in everyday life, mathematics has an important role to develop someone' intelligent character because mathematics trains one to think critically, logically, systematically and creatively. This is in accordance with the statement of the National Education Standards Agency (BNSP) which states that mathematics learning is given at every level of primary and secondary education so that students can use mathematics as a way of reasoning (logical thinking, analytical, systematic, critical, creative and cooperative skills) [2].

One of the abilities developed in mathematics learning is students' critical thinking skills. Liberma states that critical thinking is a very important ability for everyone, which is used to solve life problems by thinking seriously, actively, thoroughly and analyzing all the information they receive by including rational reasons so that every action taken is correct [3]. According to Gunawan, critical thinking students would be able to solve problems, and form the conclusions, he would gather various possibilities and make decisions in learning. Students who have critical thinking skills can also involve inductive thinking skills such as recognizing relationships, analyzing open-ended problems, determining cause and effect, and calculating relevant data in mathematics [4]. Therefore, the ability to think critically in mathematics needs to be developed because it can be used as a benchmark for the extent to which students are able to solve a mathematical problem.

A person who has good critical thinking skills, will be able to analyze ideas or ideas related to the concept given or the problems presented. With the ability to think critically, one can consider the concept that he just received carefully from all points of view. Dewey stated that critical thinking is an active, persistent (and continuous) consideration of a belief or form of knowledge that is taken for granted in terms of the reasons that support it and the continued conclusions that become its tendency [5]. Correspondingly, Ennis stated that critical thinking is reasonable and reflective thinking that focuses on deciding what to believe or do [5]. Thus, a reliable critical thinker cannot immediately accept or reject all forms of knowledge, but with sharp thinking from all angles of supporting reasons and conclusions, so as to be able to decide what can be trusted or done.

Critical thinking is the ability of a person to use his logic to get knowledge accompanied by the study of truth based on certain reasoning patterns. Reliable critical thinkers will observe, analyze, and evaluate information before deciding to accept or reject the information. If you don't have understanding, then they might also suspend their decision about that information. As Glazer argues, "critical thinking in mathematics is the ability and disposition to incorporate prior knowledge, mathematical reasoning, and cognitive strategies to

generalize, prove, or evaluate unfamiliar mathematical situations in a reflective manner" [6].

Based on the explanation about critical thinking skills above, mathematical critical thinking skills can be interpreted as the ability to use prior knowledge and mathematical reasoning in order to be able to decide all forms of knowledge to be accepted or rejected by observing, analyzing and evaluating them. The purpose of critical thinking is to be able to keep someone from inappropriate decisions so that they cannot be accounted for. Critical thinking skills of students can help students make the right decisions based on very systematic, logical, and considering various perspectives. In other words, students solve a problem with good analysis and do not guess easily or apply a formula, so critical thinking is needed by students.

But in reality in Indonesia shows that students' critical thinking skills are still low, one of which is based on the results of the Program for International Student Assessment (PISA) test in 2015. Indonesia is one of the PISA participating countries. The 2015 PISA results show that the Indonesian student's average mathematics score is 386, with an international average score of 490. This makes the 2015 PISA mathematics literacy results ranked 63rd in 70 countries. In PISA questions students are required to be able to interpret existing problems, analyze problems and evaluate problems that are given. This shows that PISA questions are questions that require students' critical thinking skills. The low ranking of Indonesia in the PISA test shows that students' critical thinking skills in Indonesia are still low.

The low ability of students' critical thinking causes education in schools to only be able to produce people who are less creative, less independent, and less flexible in solving various problems. So it is not surprising that in social life, as a reflection of the behavior of schools, frequent conflicts occur. In fact, good critical thinking skills can shape good attitudes and behavior. Facione said that if a person is able to develop his critical thinking skills then one will tend to seek the truth, think openly, analyze the problems appropriately, think systematically, express their opinions and reasons logically, have curiosity highly, and make decisions appropriately [7]. For that reason, the ability to think critically is an important thing to develop, so that students can deal with their problems both inside and outside of school.

Critical thinking ability can be developed optimally in learning if the teacher uses the right learning strategy, which is a learning strategy that can actively involve students in learning. This requires the creativity of teachers in carrying out or implementing the teaching and learning process. In learning activities, learning resources are media that can be used by teachers to involve student activity. One of the learning resources that can be used by teachers in the learning process is teaching material. Teachers are expected to be able to design or compile teaching materials that can engage students actively in the learning process which in turn can improve student success in learning, such as critical thinking skills. teaching is an important part in the implementation of education in schools. Through teaching materials teachers will be easier in carrying out learning and students will be more helpful and easy in achieving the learning competencies they are facing.

Teaching materials are learning resources that teachers can use to support the learning process. According to Widodo and Jamadi teaching materials are a set of learning tools or tools that contain learning material, methods, boundaries, and ways of evaluating that are designed systematically and interestingly in order to achieve the expected goals, namely achieving competence or sub-competencies with all its complexity [8]. Through the instructional materials arranged can be a tool that helps or facilitates students to better understand a learning concept. Like Hamdani's statement, teaching materials are information, tools and/or texts needed by the teacher for planning and reviewing the implementation of learning [9].

Teaching materials must be processed or managed first. As said by Panen which revealed that teaching materials are materials or subject matter that are arranged systematically, which is used by teachers and students in the learning process [10]. This understanding explains that a teaching material must be designed and written with an instructional principle because it will be used by the teacher to help and support the learning process.

Looking at the explanation above about the understanding of teaching materials, it can be seen that the role of a teacher in designing or compiling teaching materials is very determining the success of the learning process and learning through a teaching material. Teaching materials can be interpreted as a tool that is arranged systematically by the teacher used in the teaching and learning process with the aim to help or facilitate students in understanding a concept of learning. With the existence of teaching materials, teachers will be more coherent in teaching material to students and achieved all the previously determined competencies.

Teaching materials can be made in various forms according to the needs and characteristics of teaching materials that will be presented so that teaching materials can be useful in the teaching and learning process. The benefits of using teaching materials can be divided into two types, namely the benefits for teachers and students [10]. The benefits obtained by the teacher are teaching materials in accordance with the demands of the curriculum, not dependent on textbooks and government assistance package books, while the benefits obtained by students are creating interesting learning, motivating, reducing dependency and getting ease in learning each indicator. on learning devices compiled by the teacher.

The teaching material that is used in learning should be teaching materials that can support students to train students' thinking in understanding a concept as a basis for solving a problem and analyzing and evaluating problems independently. According to Bruner theory of learning students should learn through active participation with concepts and principles so that they gain experience and conduct experiments so that they find the concepts and principles themselves [11]. Students also need to be given the opportunity to act as problem solvers through their cognitive awareness. One strategy that actively involves students' mindsets is metacognitive strategies. Learning to use teaching materials based on metacognitive strategies is learning that is appropriate to the needs and

packaging the learning process that is more meaningful, interesting, and is expected to help students to improve their critical thinking skills.

Strategy using metacognitive is one of the learning strategies that allows students to be able to develop their critical thinking skills. Kramarski and Zoldan explained that metacognitive strategy is a learning strategy that instills awareness of how to design, monitor, and control what they know; what is needed to do; focus on learning activities; help and guide students when experiencing difficulties; and assist students in developing their self-concept while learning mathematics [12]. Thus, if this awareness is realized, then one can guard his mind by designing, monitoring and assessing what he is studying (evaluating). This is done to develop students' critical thinking skills.

In principle, people who are able to think critically are people who don't just accept or reject something [13]. They will observe, analyze, and evaluate information before whether they accept or reject information. Meanwhile, according to Schoenfeld metacognitive is related to thinking students about their own thinking and the ability to use certain learning strategies appropriately [14]. In the context of learning, students know how to learn, know the abilities and learning modalities they have and know the best learning strategies for effective learning.

In this study, the metacognitive used was its metacognitive experience. Flavell and Brown suggest that experience or regulation of metacognition is the regulation of one's cognition and learning experience which includes a series of activities that can help control their learning activities [15]. Metacognition experiences involve metacognition strategies or metacognition settings. Metacognition strategies are sequential processes used to control cognitive activities and ensure that cognitive goals have been achieved. These processes consist of planning and monitoring cognitive activities and evaluating the results of these activities. Planning activities such as determining goals and analyzing tasks help activate relevant knowledge so as to facilitate the organization and understanding of lesson material. Monitoring activities include students' attention when he reads, and makes statements or self-tests. This activity helps students understand the material and integrate it with initial knowledge. Regulatory activities include adjusting and improving students' cognitive activities. This activity helps improve achievement by monitoring and correcting his behavior when he completes the task.

II. METHODS

Before being applied in the field, teaching materials based on metacognitive strategies were developed in advance using the type of research and development. The writer chose to use the development framework of Dick, Carey and Carey which consists of 10 stages, namely [16]: Identify instructional goals, conduct instructional analysis, identify entry behaviors, write performance objectives, develop criteria reference tests, develop instructional strategies, develop and select instructional materials, design and conduct formative evaluation, instructional revise, and develop and conduct summative evaluation. The first four stages are carried out simultaneously during preliminary research. Meanwhile, formative evaluation is carried out by expert validation, readability testing and attractiveness by practitioners (teachers) and students, as well as field trials.

After the teaching materials are revised and said to be feasible, then field trials are conducted using teaching materials based on metacognitive strategies for six meetings. The subjects of the trial in this study were 72 of Year 8 students at one of Junior High School in Bandar Lampung. 37 students as an experimental class while 35 students as a control class. Sampling in this study was conducted by purposive sampling technique using classes with the same ability. Summative evaluation is done to test the product or teaching material to see the effectiveness of teaching materials on students' critical thinking skills. In the product testing phase, the research design used was pretest-posttest control group design conducted in the experimental class and control class, as proposed by Fraenkel and Wallen as shown in table 1 [17].

TABLE I. RESEARCH DESIGN

Group	Treatment		
	Pretest	***Learning***	***Posttest***
E	Y_1	Using teaching materials based on metacognitive strategies	Y_2
K	Y_1	conventional	Y_2

Note:

E : experiment class
K : control class
Y_1 : conducted pretest test instruments in experimental class and control class
Y_2 : conducted posttest test instruments in the experimental class and control class

Test instruments are used to test the effectiveness of the use of teaching materials based on metacognitive strategies on students' critical thinking skills. This effectiveness test is conducted to determine the effect of learning by using teaching materials based on metacognitive strategies on students' critical thinking skills. The test method is done by pre-test and post-test in both classes to measure students 'knowledge before and after using teaching materials based on metacognitive strategies of Mathematics learning by using 5 essay questions that correspond to indicators of students' critical thinking abilities. Indicators of critical thinking skills used in this study are indicators adopted based on Noer's opinion, namely exploring the ability to examine problems from various points of view, building meaning, and investigating mathematical ideas, identifying and establishing the truth of the concept, namely the ability to compare and associate another concept and provide reasons for the use of concepts, generalize namely the ability to complete data or information that supports, and determine general rules based on observed data, as well as clarifying and resolving the ability to evaluate and examine an algorithm and clarify the basic concepts used and develop alternative strategies in problem solving [18].

The results of the pre-test and post-test were analyzed using the average normalized gain formula to determine the improvement of critical thinking skills before and after learning

using teaching materials based on metacognitive strategies. In addition, to determine the effectiveness of the use of instructional materials based on metacognitive strategies, an analysis of the average difference in learning outcomes was analyzed using the Mann Whitney U test. Before conducting a difference test the average prerequisite test (normality and homogeneity) was carried out.

III. Results and Discussion

Field testing is the stage of knowing the effectiveness of teaching materials based on metacognitive strategies to improve students' critical thinking skills. For this reason, two equal tests were used to test whether the two classes had the same initial and final ability to think critically or not. Based on the results of the normality test and homogeneity test, it is known that the data of the initial ability of students' critical thinking in one sample in this study comes from a population that is not normally distributed and the two classes do not have the same or not homogeneous variance. Meanwhile, the data on the final ability of critical thinking students shows that the two classes do not have the same or not homogeneous variance. Therefore, hypothesis testing uses a non-parametric test, namely the Mann-Whitney U test. Using the SPPS program version 17.0, the results are shown in table 2.

In the table 2, it can be seen that the probability value (Sig.) of the initial critical thinking ability score is greater than 0.05, meaning that there is no difference in the initial critical thinking skills of students who use teaching materials based on metacognitive strategies with the initial ability to think critically mathematical students who only use books available at school. While the probability value (Sig.) of the final score of students' critical thinking skills is less than 0.05. This shows that there is a significant difference between the final ability of students' critical thinking mathematically using teaching materials based on metacognitive strategies and students who only use books available at school.

TABLE II. Mann-Whitney U Test Results Critical Thinking

Test Critical Thinking Ability	**Learning**	**Average of Rank**	**Z**	***Df***	***Sig.* (2-tailed)**
Initial Score	Learning by using teaching materials based on metacognitive strategies	40.00	-1.463	70	0.143
	Learning by using books available at school	32.80			
Final Score	Learning by using teaching materials based metacognitive strategies	47.49	-4.588	70	0.000
	Learning by using books available at school	24.89			

It can be seen that the average posttest score of the class using teaching materials based on metacognitive strategies was 47.49 higher than the classes that did not use teaching materials based on metacognitive strategies which amounted to 24.89. Thus, it can be concluded that students 'critical thinking abilities that use teaching materials based on metacognitive strategies are higher than those who did not use. In other words, teaching materials based on metacognitive strategies are effective to improve students' critical thinking skills.

The next analysis is the analysis of the gain index of critical thinking skills of students to find out the criteria for improving students' critical thinking skills in both classes. After calculating the gain index from the pretest and posttest data obtained the data presented in table 3 below.

TABLE III. Gain Index Data for Students' Critical Thinking Ability

Class	**Score**	**N**	X_{min}	X_{max}	$\bar{x}$	***Average N-gain***
Eksperiment	*Pretest*	37	0	16	7.95	0.507
	Posttest		31	72	54.62	
Control	*Pretest*	35	0	15	6.23	0.361
	Posttest		20	50	40.17	
Maximum Score Ideal = 100						

The table 3 above shows that the average gain index of critical thinking students who use teaching materials based on metacognitive strategies is higher than the average gain index of critical thinking students who do not use teaching materials based on metacognitive strategies. Meanwhile the average gain index of the experimental class is 0.507. This shows that the improvement of students' critical thinking skills using teaching materials based on metacognitive strategies is greater than the improvement of critical thinking skills of students who did not use teaching materials.

It can be seen that students' critical thinking skills who learn using teaching materials based on metacognitive strategies are better than students who learn by using only available teaching materials at school. The conclusion obtained from this study was obtained from the standard of effectiveness caused by several factors. The first factor is the formulation of a metacognitive strategy to be included in teaching materials so that it does not cause inequality between the learning process and the media used. Hamalik argues that the learning method is one of the ways used by teachers in making relationships with students during learning to achieve the goals set so that learning becomes more interesting and not boring [19]. This thing makes the critical thinking abilities students' which used teaching materials based on metacognitive strategies are more effective than those who did not use. If students are able to apply metacognitive strategies in cognitive activities, he/she will be a good problem solver.

With metacognitive strategies students are able to always design the best strategy in choosing, remembering, recognizing, organizing the information they have and solving the problems they face. In line with Schoenfeld's opinion which put forward more specifically three ways to explain metacognition in mathematics learning, namely beliefs and intuition regarding any mathematical ideas prepared to solve

mathematical problems and how those ideas form ways to solve mathematical problems knowledge of the thinking process involves how accurate a person is in drawing his thinking process, as well as self-awareness or self-regulation regarding how well a person is in maintaining and managing what must be done when solving problems and how well someone uses input from observations to direct solving activities problem [20].

The second factor is the presentation of the questions of critical thinking ability through interestingly presented learning, so that students are interested in actively participating in learning and discovering mathematical concepts learned, so that students' unconscious ability to think critically through discussion in understanding a concept and connecting them with other concepts in general. Van Gelder argues that to improve critical thinking skills requires training and is actively involved in critical thinking skills. Van Gelder recommends increasing critical thinking in the form of active involvement, transfer of learning, understanding theory, ability to map, the ability to identify bias and being open to what must be considered as 'truth' [21]. The results of various studies support the fact that by training students can increase their level of critical thinking skills [22]. Reichenbach's research shows that students can expand their thinking abilities, including clarity, accuracy, accuracy, relevance, depth, breadth and logic through practice [23].

IV. CONCLUSION

Based on the results of data analysis and discussion, it was concluded that teaching materials were based on metacognitive strategies to improve mathematical critical thinking skills, which began with a preliminary study that showed the need for the development of teaching materials based on metacognitive strategies. Validation results show that the syllabus, lesson plan and teaching materials based on metacognitive strategies are feasible to use and are included in the valid category. The results of the initial field trials regarding readability and interest in teaching materials indicate that the developed teaching materials are in the practical category. The final result of this development research is teaching materials based on metacognitive strategies to improve students' critical thinking skills. The ability to think critically mathematically with learning that uses teaching materials based on metacognitive strategies is more effective than the ability to think critically mathematically did not use teaching materials.

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