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Development of Teaching Materials Based on Metacognition Approach to Improve Mathematical Ability Students in State 17 Middle Medan

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Abstract This study aims to describe: 1) the validity, practicality and effectiveness of the teaching materials developed, 2) describe the improvement of students' mathematical reasoning abilities using the developed teaching material. The development of teaching materials based on the metacognition approach uses a 4-D model developed by Thiagarajan, Semmel and Semmel. The subjects in this study were students of class VIII-8 and VIII-9 SMP Negeri 17 Medan. From the results of field trials I and field trials II obtained: 1) teaching materials that meet valid, practical and effective criteria, 2) there is an increase in mathematical reasoning abilities.

Keywords: *teaching materials, metacognition approach, 4-D development model, mathematical reasoning ability*

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1. Introduction

In learning mathematics, students must have several abilities (*standard process*). Based on the *National Council of Teacher Mathematics* (NCTM) [1] states that:

School mathematics standards include content standards (*mathematical content*) and process standards (*mathematical processes*). The standard covers the process of problem solving *(problem solving),* reasoning and evidence *(reasoning and* proof), the links *(connections),* communication *(communication),* and representation *(representation)*. The standard of the process together is the basic skills and understanding needed by students in the 21st century.

The skills above are skills that need to be developed by students, one of which is reasoning. Reasoning is a process of thinking using data or facts in drawing a conclusion. Mathematical reasoning ability is a mental process that must be built continuously through various contexts (Brodie, [2]). Based on the findings of the researcher when observing at SMP Negeri 17 Medan, it was seen that students' reasoning ability in working on math problems was still very low. This is indicated by the overall students are not able to complete the test of mathematical reasoning ability correctly, even most of them did not answer at all. Based on the results of the interviews, students revealed that this test was a very difficult test and students had never answered such questions. The questions asked also make students confused about the right or correct answers.

Not only based on observations made by researchers, research conducted by Rosnawati [3] concluded that, "the lowest average percentage achieved by Indonesian students is in the cognitive domain at the reasoning level of 17%. This shows the need to improve students' reasoning abilities in primary and secondary schools".

Teaching material is an element of learning that is important to be considered by the teacher. Through teaching materials students can learn things that are needed in an effort to achieve learning goals. Therefore, 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.

Good teaching materials have valid, practical and effective criteria. According to Nieveen [4] there are criteria in determining the quality of the results of the development of teaching materials, namely: (1) *validity* (valid); (2) *practivally* (practical); and (3) *effectiveness* (effective). So that it can be stated that quality teaching materials fulfill those three aspects.

In addition to the development of teaching materials, to improve students' mathematical reasoning abilities, a change in the approach to learning mathematics from the teacher-centered activities to the situation at the center of attention is needed for students. So that students are able to understand concepts with awareness of thinking in the learning process in the classroom. One alternative that allows can improve thinking skills such as mathematical reasoning, so that students are able to understand the concept of awareness of thinking in the learning process in the classroom is a metacognition approach. According to Fauzi [5], the concept of metacognition is awareness of thinking, including awareness of what one knows (metacognitive knowledge), what one can do (metacognitive

skills), and what one knows about one's own cognitive (metacognitive experience).

This refers to the development of research material development model of the 4-D*(four-D*Model) proposed by Thiagarajan and Semmel [6] which consists of four stages, namely the definition phase *(define),* design *(design),* development *(develop),* and spread (*disseminate*). The 4-D development model is used by researchers because the basis for developing teaching materials (not learning systems), the implementation stages are divided in detail and systematically, and in its development involves expert judgment so that before the trial in the field the teaching materials are revised based on the assessment, suggestions and input from experts.

2. Research Method

This research is a development research with the Thiagarajan 4-D model, which consists of four stages, namely define, design, develop and disseminate.

2.1. Research Subjects and Objects

The subjects in this study were eighth grade students of SMP Negeri 17 Medan in the academic year 2017/2018, while the objects in this study were the development of teaching materials based on the metacognition approach.

2.2. Procedures for Developing Learning Tools

This research is divided into two stages, namely 1) development of teaching materials which include RPP; BG; BS; LAS; and TKPM; 2) testing teaching materials based on metacognition approaches in class VIII-8 and VIII-9.

2.3. Instruments and Data Analysis Techniques

The instruments used in this study are instruments for measuring the validity and effectiveness of learning devices developed, namely validation sheets, and tests.

2.3.1. Validity of Teaching Materials

Teaching materials are validated to experts, namely five validators by giving a score of 1 to 5 in each assessment column based on aspects: (1) format, (2) language, (3) content, and (4) illustration. Furthermore, expert judgment as a whole is processed by calculating the average score to get the evaluation criteria validity which is invalid, less valid, quite valid, valid, and very valid.

2.3.2. Increasing Mathematical Reasoning Ability

The increase in mathematical reasoning ability is calculated by classical completeness values andformula *N-gain* from Hake [7] as follows:

$$N-gain=\frac{skor\ \ postest-skor\ \ pretest}{skor\ ideal-skor\ \ pretest}.$$

With the gain index criteria as in the following table:

Score Gain score	Interpretation
$g \geq 0.7$	High
$0.3 \leq g < 0.7$	Medium
$g < 0.3$	Low

3. Research Results

3.1. Description of the Development Phase of Materials Teachings

The results of the development of teaching materials using the Thiagarajan 4D model are described as follows:

3.1.1. Define

The initial preliminary analysis was carried out, namely determining the basic problems needed in the development of learning materials. Student analysis is a study of the characteristics of students VIII Medan 17 Middle School in accordance with the design and development of Statistics material. At this stage identification of the main concepts of Statistics material, then arranging it into the form of the structure of individual concepts into critical and relevant matters. The task analysis is carried out to identify the stages of completion of tasks carried out by students at the time of learning which refers to the analysis of concepts, in addition to the details of the task analysis for statistical material referring to the competencies and indicators to be achieved. The formulation of learning objectives is a reference in designing teaching materials based on the metacognition approach and in the preparation of tests.

3.1.2. Design

The purpose of this planning phase is to design mathematics teaching materials based on metacognition approaches. In this stage the preparation of teaching materials is carried out including: preparation of tests, media selection, format selection, and initial design.

3.1.3. Develop

The purpose of the development phase is to produce a *draft* of revised teaching materials based on expert input and then try out limited and analyzed to produce *Draft II.* The results of *Draft II were* then trialed to the field and then analyzed and revised to produce *Draft III* or *Final Draft*, in order to obtain valid, practical and effective teaching materials.

3.1.4. Disseminate

The deployment phase is intended to socialize teaching materials that have been tested. This activity is carried out in a limited way to the field trial school teacher discussion forum, the result of this stage is to recommend to all teachers to use this teaching material as one of the learning alternatives in Statistics material.

3.2. Test Results I

3.2.1. Capacity Enhancement Student Mathematical Communication in Test I

Improved students' mathematical reasoning ability in the first trial was seen through the completeness of learning

outcomes and *N-Gain* from the results of the *pretest* and *posttest* mathematical reasoning abilities in the I trial. From the data obtained, students who received anscore *N-Gain* ranged from g <0.3 as many as 16 students in the "low" category, and received anscore *N-Gain* stretched 0.3 ≤ g <0.7 with 17 students in the "moderate" category. The following is a picture of student learning completeness.

No	Description	Value	
		Pre-Test	*Post-Test*
1	Top-Rated	65	75
2	Lowest Value	15	50
3	Average Average	47.42	65.76
4	Percentage of Classical completeness	15.15%	66.67%

Figure 1. Completeness of student learning outcomes

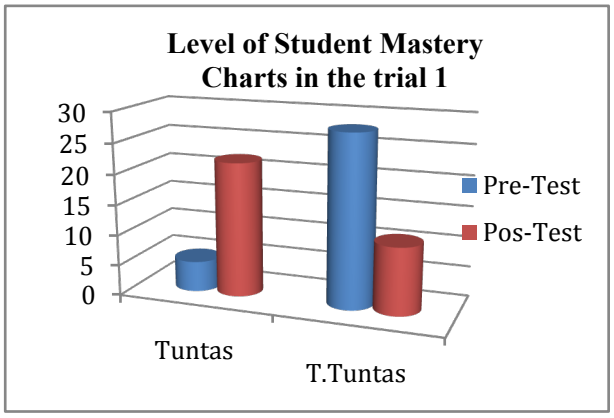

Figure 2. Graph of student learning completeness

3.3. Trial Results II

3.3.1. Improvement of Students 'Mathematical Reasoning Ability in Trial II

Improved students' mathematical reasoning ability in the second trial was seen through the completeness of learning outcomes and *N-Gain* from the results of the *pretest* and *posttest* mathematical reasoning abilities in the II trial. From the data obtained, students who received anscore *N-Gain* ranged from g <0.3 as many as 15 students in the "low" category, got anscore *N-Gain* stretched 0.3 ≤ g <0.7 as many as 17 students in the "moderate" category, and got anscore *N-Gain* stretched from g ≥ 0.7 as many as 7 students in the "high" category. The following is a picture of student learning completeness.

No	Description	Value of	
		Pre-Test	Post - Test
1	Highest Value	85	100
2	Lowest Value	45	70
3	Average	64.23	82.18
4	Percentage of Classical completeness	51.28%	94.87%

Figure 3. Completeness of student learning outcomes

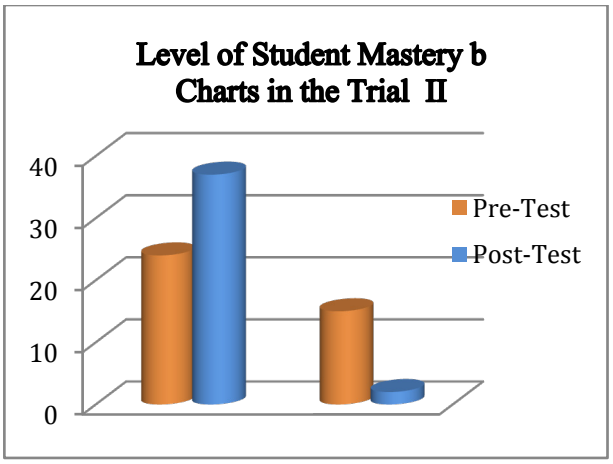

Figure 4. Graph of completeness of student learning outcomes

4. Discussion of Research Results

4.1. Increased Mathematical Reasoning Ability Students Use Teaching Materials Based on Metacognition Approach that Was Developed

Data obtained fromresults *posttest* of mathematical reasoning abilities of students in trial I and trial II were analyzed to improve mathematical reasoning ability students by comparing students 'average scores obtained from theresults *posttest* of students' mathematical reasoning abilities in the first trial and II test. The description of increasing students' mathematical reasoning abilities using teaching materials based on the metacognition approach developed in trials I and II is shown in the following table.

Description	*Post-Test* Mathematical Reasoning Ability On I	*Post-TrialTest* Mathematical Reasoning AbilityIn Trial II
Highest Value	75	100
Lowest Value	50	60
Average	65.76	81.41
N-gain average	0.33	0.45

Figure 5. Results of *post-test* test I and trial II

Based on the picture above, the results of the analysis of increasing mathematical reasoning abilities students in trial I and trial II showed that the average score of students in the results *posttest* of the first trialwas 65.76%, increasing to 81.41% in the trial II. This is in accordance with the data analysis of the increase in students' mathematical reasoning abilities in chapter III, namely an increase in mathematical reasoning ability seen from the average results *posttest,* of trial I and IIthus it is known that there is an increase in the average mathematical reasoning ability of students of 15.65 %. Can also be seen in the following picture.

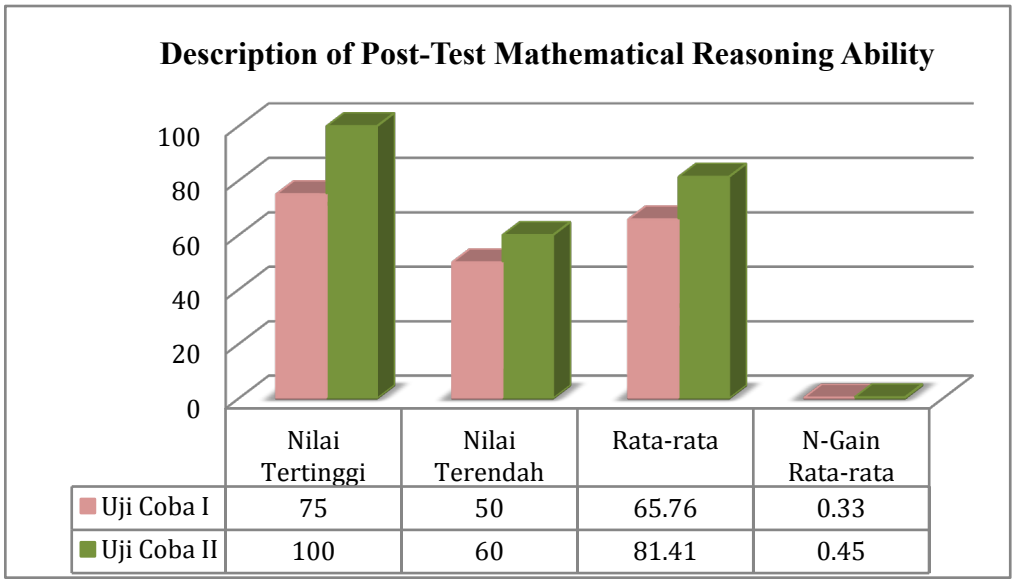

Figure 6. Graph ofresults *post-test* of trial I and trial II

5. Conclusions

Based on the results of the analysis and discussion in this study, it was stated that it was concluded as follows:

Students' mathematical reasoning abilities using teaching materials based on metacognitive approaches increased, in terms of: (1) the classical completeness *posttest* of the first trialwas 65.76%, increasing to 81.41% in the trial II; and (2) I *N-Gain* trial of 0.33 with the category "moderate" increased to 0.45 with the category "moderate" in the trial II.

6. Suggestion

Based on the results of the research and conclusions above, it can be suggested as follows:

Teaching materials developed based on the metacognition approach are able to improve students' mathematical reasoning abilities and are still limited to statistical material, so it is suggested to other teachers and researchers to develop them in other material or even other relevant science.

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