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Development of Problem-Based Learning Devices to Improve Students Metacognition Ability in SMA Negeri 1 SeiSuka

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Abstract: *This study aims to: 1) develop problem-based learning devices that meet valid, practical, and effective criteria, 2) improve students' metacognition abilities by using problem-based learning devices developed. This development research uses Four-D development model completed in four stages: define, design, develop, and disseminate. Learning devices generated from this research are: learning implementation plan (RPP), student activity sheet (LAS), teacher handbook (BPG), student book (BS), and metacognition ability test (TKM). Subjects in this study were students of class XI in SMA Negeri 1 SeiSuka, while the object in this study is a problem-based learning devices developed on linear program materials. The result of the research shows that: 1) Learning devices developed meet the valid, practical and effective criteria in terms of their respective criteria, 2) there is improvement of students' metacognition ability using problem-based learning devices developed.*
Keynote : *Development, Learning Devices, Metacognition Ability, Problem-Based Learning*

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I. Introduction

Mathematics has a very important role in life, because basically math is required by all disciplines of science. Mathematics also plays an important role in the development of modern technology, various disciplines and advances the human mind. Given the importance of mathematics in life, it should be taught at every level of mathematics education. Cockroft (Abdurrahman, 2012) states that "mathematics needs to be taught to students because it is always used in all aspects of life". One of the goals of learning mathematics in the 21st century is that students are able to have high-level thinking skills. Mustafa dkk (2017) states in the study of mathematics, the ability to think and to solve the problem is one of the most important abilities.

The main purpose of students in learning mathematics is to solve problems (Musser et al., 2011). The ability of students to solve problems is one benchmark for the success of students in learning mathematics. Students can develop a positive attitude in learning when solving problems. The attitude is unyielding, diligent and confident in unusual situations. This attitude positively affects students' ability to solve problems (Pimta, et al, 2009).

Metacognition ability becomes very important because it can train students' mathematical learning comprehension. Chairani (2016) states that the importance of metacognition because of metacognition implications not only in learning mathematics but in monitoring the thinking process of students to develop the formation of positive characters and personality that can be developed in every learning. On the other hand, TEAL (2010) states constructing mathematic understanding requires both cognitive and metacognitive elements, learners "construct mathematic knowledge" using metacognitive, and they guide, regulate, and evaluate their learning using metacognitive.

Metacognition has advantages in which one tries to reflect on the way of thinking or contemplating the cognitive processes it performs. Metacognition is also a process by which a person thinks about thinking in order to build a strategy for solving problems. Aljaberi&Gheith (2015) says that "metacognition as thinking in thinking, metacognition is the ability where the object of thinking is the process of thinking that happens to yourself". Students are said to have Metacognition Ability if in problem solving students are able to fulfill the following stages: (1) develop action plan, (2) monitor problem solving action, and (3) evaluate problem solving action (NCREL, 2007).

However, based on preliminary observations in SMA Negeri 1 SeiSuka, the facts show that students' metacognition ability is still low. The low ability of students' metacognition is evident from the results of diagnostic tests in the form of essays given to 36 students. Of the questions asked, 6 students or 16.67% can answer correctly, 27 students or 75% answered wrong and 3 students or 8.33% did not answer. When viewed from the awareness of thinking or in metacognition, students are still using thoughts without awareness where students seem to solve the problem by trial and error. Students are not able to describe their thinking process well so they do not get the answer with the right solution. Based on the results of interviews to teachers in the field of mathematics study, so far metacognition ability is not a focus in learning activities. On the other hand, researchers found that no teacher has a learning devices that focuses on training students' metacognition abilities.

The findings in the field also show that the low ability of metacognition in solving the problem because the learning model used by the teacher has not been right on target. The commonly used model is direct learning that is not focused on practicing Metacognition Ability in solving problems. We recommend that the learning model used should be able to make students active in learning activities, making learning meaningful, and able to train students to get used to metacognition in solving problems. One of the learning models that is expected to be in line with the mathematical characteristics and curriculum expectations that apply at the moment is a problem-based learning model. As Arends (2012) suggests problem-based teaching is a learning approach in which students work on authentic issues with the intent of composing their own knowledge. Trianto (2009) also said that the application of PBL in learning has one goal, namely to make students become independent learners. In mathematics learning, there is no single learning resource that can meet all kinds of learning process objectives (Aufa et al, 2016). Therefore, in this research, we need to develop the appropriate learning devices to train and improve students' metacognition ability and to achieve the learning objectives. Based on the description, the implementation of PBL model is expected to be an alternative to create a good learning in improving metacognition ability in solving mathematical problems.

II. Literatures

2.1. Metacognition Ability

Metacognition is a thought process involving control of its own cognitive activity. Wellman (Chairani, 2016) states that metacognition is a form of cognition, a high-level thinking process that involves active control in cognition activities. It can be simply defined as thinking about thinking or as a "person's cognition about cognition". Simply put, metacognition is thinking in thinking (Jayapraba 2013). As Schoenfeld (1992) says "metacognition is thinking about our thinking and control, self-regulation, and belief and intuition. Metacognition has advantages in which the student tries to reflect on the way of thinking or contemplating the cognitive processes it performs. Moore (Chairani, 2016) defines metacognition "as an individual's knowledge of various aspects of thinking and adapting cognitive activity in order to promote more effective comprehensiveness". On the other hand, Flavell (Jonnasen, 2000) The ability of metacognition is one's awareness of how he or she learns, the ability to assess the difficulty of a problem, the ability to observe the level of self-understanding, the ability to use information to achieve goals and the ability to assess self-learning progress.

In conjunction with learning, students who use metacognitive well will be critical thinkers, good problem solvers, and good decision makers rather than those who do not use metacognition. In relation to solving mathematical problems, one's success in solving problems is also influenced by metacogniac activity (Panoura, 2005). The relationship of cognitive and metacognitive activity in a model is referred to as a metacognitive activity model during a problem-solving process. This model illustrates how cognitive activity starts from observing the problem to finding answers. Then to form metacognitive activities learners need to recognize the purpose and process of cognitive activity.

Based on some expert opinions, the ability of metacognition is the ability to realize, manage, and control the thinking process itself. Metacognition ability indicators are based on NCREL (2007): (a) developing action plans, (b) organizing or monitoring actions and (c) evaluating actions. Furthermore NCREL (TEAL, 2010) provides guidance on metacognition questions in three components. Some of the metacognition questions are modified as follows:

When you develop an action plan, ask yourself:

- What initial knowledge helps in solving this problem?
- What did I do first after reading the problem?
- What information is remembered from the problem?

When you set or monitor an action, ask yourself:

- What do I need to do if after reading the question, but I do not understand it?
- How do my strategies solve the problem?
- Am I sure I have chosen the right way? Why is that

When you evaluate the action, ask yourself:

- Why am I using that way to solve a problem?
- How can I re-examine the correctness of the problem?
- What did I learn after solving the problem?

In this research, metacognition questions are used as assistance to build student metacognition in solving the given problem. Furthermore Schwartz and Perkins (Laurens, 2010) stated that the metacognition ability of students in solving can be distinguished in 4 levels, namely: 1) Tacit Use is the use of thought without consciousness. This type of thinking is concerned with decision making without thinking about the decision. 2) Aware Use is the use of conscious thought. This type of thinking relates to students' awareness of what and why students do that thinking. 3) Strategic Use is the use of strategic thinking. Types of thinking relate to the individual arrangement in his thinking process consciously by using specific strategies that can improve the accuracy of his thinking. 4) Reflective Use is the use of reflective thinking. This type of thinking relates to individual reflection in the process of thinking before and after or even during the process taking into consideration the continuation and improvement of the thought result.

2.2. Problem-Based Learning (PBL)

Problem-based learning is a learning model that uses problems as the starting point of learning. The problems that can be used as a means of learning are problems that meet the real-world context, which is familiar with the daily life of the students. According to Arends (2012) the questions and problems raised must meet several criteria, namely: authentic, clear, easy to understand, broad and in accordance with the purpose of learning, and useful. Sinaga (2007) states that in PBL a problem raised to students should be able to arouse students' understanding of the problem, an awareness of the gaps, knowledge, solving problems and the perception that they are capable of solving the problem.

Eggen and Kauchak (2012) mentions problem-based learning is a set of teaching models that use problems as a focus for developing problem-solving skills. Arends (2012) suggests that problem-based teaching is a learning where students work on authentic issues with the intent to develop their own knowledge, develop inquiry and higher-order thinking, develop independence and confidence. Dewey (Trianto, 2009) study based on the problem is the interaction between the stimulus with the response, is the relationship between the two directions of learning and the environment. The environment provides input to students in the form of help and problems, while the brain's nervous system effectively interprets the aid so that problems encountered can be investigated, assessed, analyzed and solved properly.

Tan (Rusman, 2011) adds that problem-based learning is the use of the various intelligences needed to confront real-world challenges, the ability to deal with new things and complexities. Liu (2005) explains that there are characteristics of problem-based learning that are: 1) Learning is student-centered, 2) Authentic problems form the organizing focus for learning, 3) Learning occurs in small groups, and 5) Teachers act as facilitators. Based on some expert opinions above, then the problem-based learning is a learning that faces students on practical issues as a foothold in learning or in other words students learn through the problems. The problem-based learning indicator in this study refers to Arends (2012) consisting of five learning stages: (1) student orientation on the problem, (2) organizing students to learn, (3) assisting individual and group investigations, (4) develop and present the work, and (5) analysis and evaluation of problem solving.

2.3. Quality of Learning Devices

Rochmad (2012) states that "to find the quality of the outcomes of model development and learning devices is required three criteria: validity, practicality, and effectiveness". Along with this Nieveen (2007) says that "a development of learning component is said to be good if the model is: (1) valid; (2) practical; and (3) effective". However, in this study the quality of instructional devices is only focused on valid and effective criteria, because it does not find the instrument right in measuring the practicality of instructional devices. Akker (1999) states "validity refers to the extent that the design of the content is based on the state-of-the art knowledge (content validity) and that the various components of the intervention are consistently linked to each other (contruct validity)" . The components of the validation of the validation criteria in general are: format, language, illustrations, content and learning objectives (Akker, 1999).

According to Akker (1999) practically refers to the extent that the user (or other experts) consider the intervention as appealing and usable in normal conditions. While Nieveen (2007) states practicality is reviewed by "Expected: The intervention is expected to be usable in the settings for which it has been designed and developed. Actual: The intervention is usable in the settings for which it has been designed and developed ". Therefore the practicality in this research is reviewed based on: 1) validator assessment about ease of use of learning device, and 2) practicality of instructional device.

Herman (2012) states that the effective criteria of a learning if it meets 3 of the 4 criteria of effectiveness, namely the achievement of learning achievement, student activity, positive student response and the ability of teachers to manage learning. Mulyana, et al (2013) states the effectiveness analysis using learning completeness analysis, student activity analysis, learning achievement analysis of test class. While Mustafa et al (2017) states effectiveness can be reviewed based on the completeness of learning outcomes, student activities, and positive responses of students. Based on some expert opinions, the effective criteria in this study focused on: (1) mastery of students' learning outcomes classically, (2) student activities, and (3) positive student responses.

III. Research Methods

The type of this research is qualitative descriptive research. This research is a type of research that aims to describe the ability of students' metacognition in solving mathematical problems on problem based learning.

3.1. Learning Device Development

The learning devices that were developed in this research were the Lesson Plans, Student Activity Sheets (LAS) Student Book (BS), Teacher Handbook (BPG) and Research Instrument in the form of Metacognition Ability Test (TKM). Learning device development is done by applying 4-D development model (Thiagarajan et al, 1974) with four development stages: define, design, develop, and disseminate. The design of device development in this study can be seen in Figure 1 below:

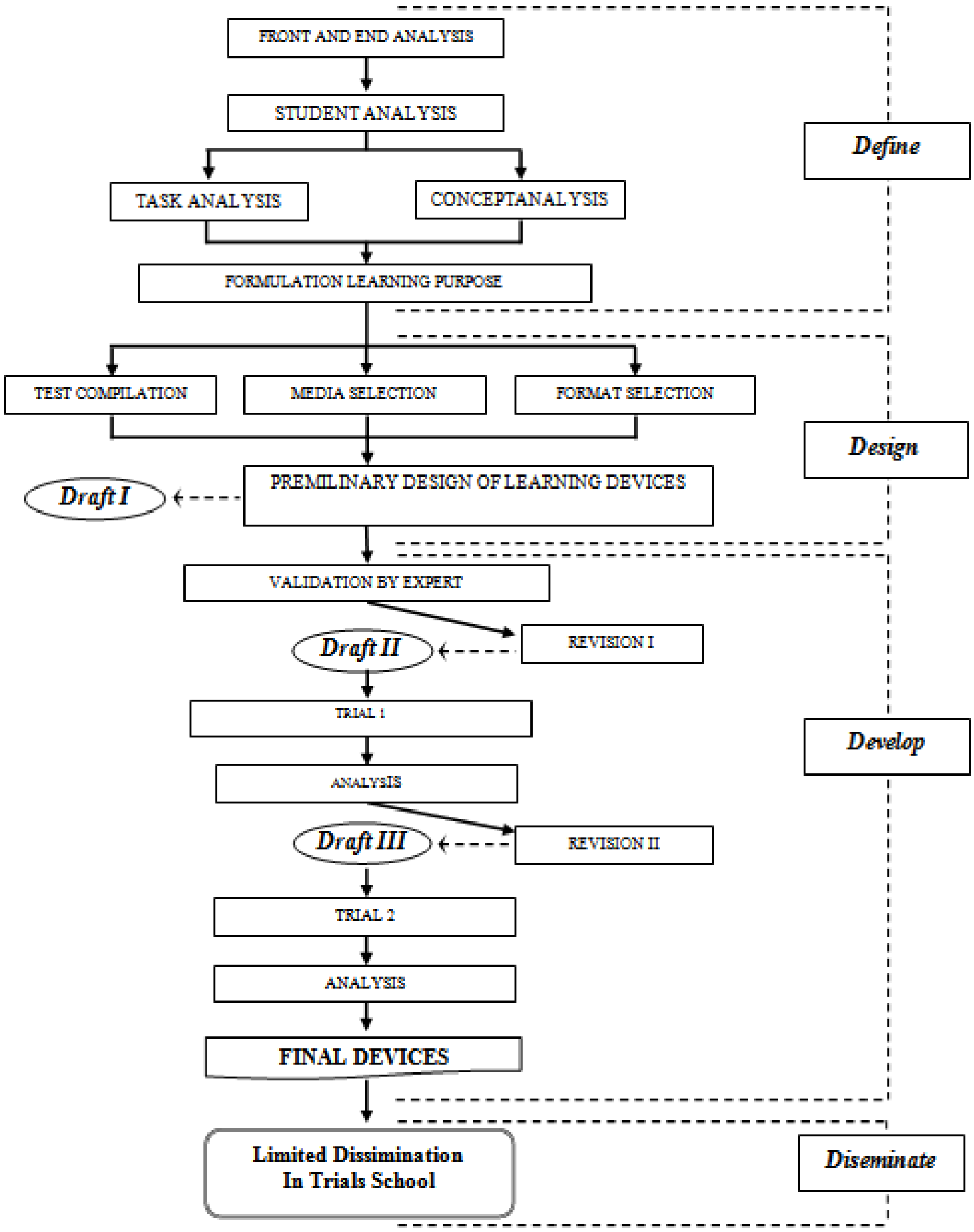

Figure 1. Research Design

3.2. Instrument and Data Analysis Technique

The instruments used in this study include instruments for assessing the quality of instructional devicescovering aspects of prevalence, practicality and effectiveness. Instruments used in the form of observationsheets, questionnaires, and tests. For more details can be seen in Table 1 below:

Table 1. Research Instruments

Aspect	Instruments	The Observed Data	Respondent
The Validity of Learning Devices	Validation Sheet	Validity of RPP, LAS, BS, BPG and TKM	Expert/Practitioners
The Practicality of LearningDevices	ValidationSheet	Practically of RPP, LAS, BS, BPG and TKM	Expert/Practitioners
	ObservationSheet	LearningDevicesImplementation	Observer
The Effectiveness of Learning Devices	Test	Metacognition Ability Test	Research Subject
	Observation Sheet	Students Activity	Observer
	Questionnaire	Student Response	Research Subject

Learning devices are said to be valid if they meet the criteria of content validity and construct validity. Learning devices meet the expected content validity if the average validator rating of all learning devices is at minimum valid criteria with an average of ≥4 (Mustafa, et al 2017). If not fulfilled, it is necessary to re-do the validation activities. And so on until obtained learning devices that meet the validity of the contents. Subsequent construct validity of metacognition test. Prior to use for field trials, metacognition test items were tested outside the study subjects to measure validity and reliability. To measure the validity of item can use product moment correlation formula and to calculate the reliability coefficient of test items used *Alpha-Cronbach* (Arikunto 2012).

The effectiveness of learning devices is reviewed based on: 1) Students' learning completeness is classically met if ≥ 85% gets test scores ≥ 2.51 from a scale of 4; 2) student activity fulfilled if fulfill ideal time tolerance percentage specified, and 3) student response fulfilled if classically ≥ 80% subject give positive response (Mustafa et al, 2017). The criteria of student activity based on the achievement of the ideal time tolerance set as follows:

Table2. PercentageofIdealTimeand StudentActivityToleranceLimit

Student Activity Category		Ideal Time	PWI Tolerance Interval	Ideal Criteria
1.	Pay attention / listen to teacher / friend explanations	25 % from WT	20 % ≤ PWI ≤ 30 %	Three of 1, 2, 3, 4, 5 are fulfilled and 3, 4 must be met
2.	Reading student's books (BS) and student activity sheets (LAS)	15 % from WT	10 % ≤ PWI ≤ 20 %	
3.	Take note of the teacher's explanations, notes from books, solve problems in the LAS, summarizes the work of the group	30 % from WT	25 % ≤ PWI ≤ 35 %	
4.	Discuss, ask ideas, between students and friends or between students and teachers, and draw conclusions of a procedure or concept	30 % from WT	25 % ≤ PWI ≤ 35 %	
5.	Perform behavior that is not relevant to learning	0 %from WT	0 % ≤ PWI ≤ 5 %	

Source: Aufa et al(*2016*)

Explanation:
PWIistheidealtimepercentage
WTisthetimeavailableateachmeeting.

After learning devices meet valid, practical and effective criteria, it is reviewed the improvement of students' metacognition ability based on: 1) the increase of classical average value based on TKM result and 2) improvement of average value of each metacognition capability indicator based on TKM result from trial I to trial II.

IV. Result

The following is the result of the study obtained based on the experimental learning device in SMA Negeri 1 SeiSuka with two trials. The results of the tests described included: 1) validation of learning devices, 2) practicality of learning devices, 3) the effectiveness of learning devices, and 4) improvement of students' metacognition ability.

4.1. Description Validity of Learning Devices

Based on the validator's assessment, it was found that the learning devices developed obtained the assessment as shown in Table 3 below:

Table 3.The Result of Content Validation of Learning Devices

No	Learning Devices	Average Value of Total Validity (V_a)	Validation Level
1	Learning Implementation Plan (RPP)	4,38	Valid
2	Student Activity Sheet (LAS)	4,38	
3	Teacher Handbook (BPG)	4,41	
4	Student Book (BS)	4,41	
5	Metacognition Ability Test (TKM)	-	All Items Valid

Based on Table 3 it is found that all learning devices meet the valid criteria as it obtains an overall average rating of 4≤V_a <5. Then the results of the instrument test show that all items of test metacognition ability meet the valid criteria. the problem-based learning devices developed meet the criteria of content validity and construct validity.

4.2. Description of Practically and Effectiveness of Learning Devices

4.2.1. Description of Practically and Effectiveness of Learning Devices in Trial I

The practicality criteria of learning devices based on the validator assessment are met, because all validators assess the developed learning devices can be used easily. Implementation of learning devices is met, in terms of the average of all learning meetings obtained a percentage of 81.67% ≥ 80% (good category). Based on these descriptions, the learning devices developed meet the practical criteria. Based on result of trial I obtained posttest data of students metacognition ability as in Figure 2 below:

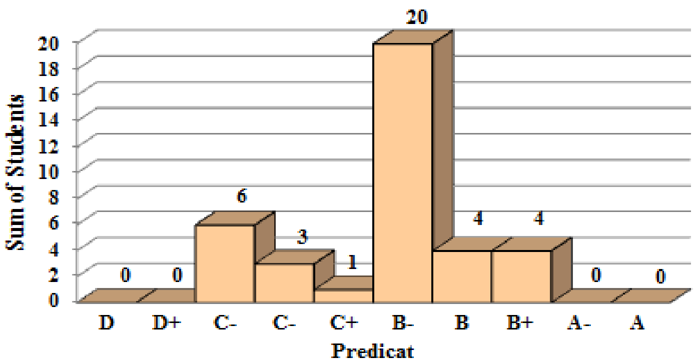

Figure 2. Level of Mastery of Student Metacognition Skill in Trial I

The result of the students' metacognition ability test showed that the total number of subjects completed or received ≥ 2.51 reached 28 students (73.69%) of 38 students who took metacognition ability test. Based on the results of the completeness criteria of student learning outcomes have not been achieved classically.

Furthermore, the effectiveness criteria based on student activity observation can be seen in Table 4 below:

Table 4. Average Percentage of Ideal Time Student Activity Trial I

Meeting	Average Time of Student Activity for Each Category (in percent)				
	1	2	3	4	5
I (2 x 40')	37,78	12,22	18,89	25,56	5,56
II (2 x 40')	30,00	16,67	31,11	21,11	1,11
III (2 x 40')	24,44	7,78	33,33	28,89	5,56
Average	**30,74**	**12,22**	**27,78**	**25,19**	**4,07**
Interval Tolerance	20 % ≤ PWI ≤ 30 %	10 % ≤ PWI ≤ 20 %	25 % ≤ PWI ≤ 35 %	25 % ≤ PWI ≤ 35 %	0 % ≤ PWI ≤ 5 %
Criteria	Fulfilled	Fulfilled	Fulfilled	Fulfilled	Fulfilled

Based on Table 4, all aspects of observed activity meet the ideal time tolerance criteria specified, except the first indicator. So effectiveness based on the effectiveness of students in learning activities are met. This is because the minimum criteria that is 3 of 5 indicators are met with indicators 3 and 4 are met. Then based on the test results also obtained the percentage of the average total positive response of students to the tools and learning activities in the first test of 82.26%. Therefore, students' responses are also fulfilled because students who respond positively to the components and learning implementation achieve ≥ 80%.

Based on the above results obtained that the learning device only meets the aspects of students' active activities and positive responses of students, but has not fulfilled the completeness criteria of learning outcomes are classically defined. Thus the learning device developed has not met the effective criteria. Therefore a revision of the learning device must be revised and re-tested to produce an effective learning devices.

4.2.2. Descriptionof Practically and Effectiveness of LearningDevicesin Trial II

The practicality criteria of learning devices based on the validator assessment are met, because all validators assess the developed learning devices can be used easily. Implementation of learning devices is met, in terms of the average of all learning meetings earn a percentage of 87.67% ≥ 80% (good category). Based on these descriptions, the learning devices developed meet the practical criteria. Pursuant to result of trial II obtained data posttest ability of student metacognition as in Figure 3 following:

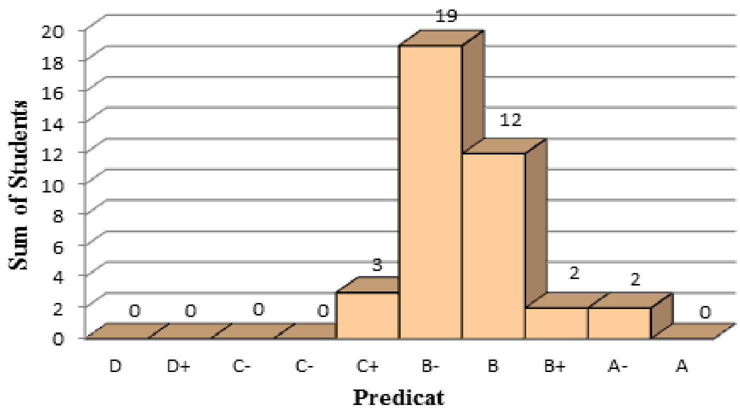

Figure 3. Level of Mastery of Student Metacognition Skill in Trial II

The result of metacognition ability test of student in trial II showed that the total number of subjects completed or got ≥ 2.51 reach 35 students (92,11%) from 38 students who take metacognition ability test. Based on the results of the completeness criteria of student learning outcomes have not been achieved in Classical. Furthermore, the effectiveness criteria based on student activity observation can be seen in Table 5 below:

Table 5. Average Percentage of Ideal Time Student Activity Trial II

Meeting	**Average Time of Student Activity for Each Category (in percent)**				
	1	**2**	**3**	**4**	**5**
I (2 x 40')	25,56	11,11	22,22	38,89	2,22
II (2 x 40')	31,11	14,44	22,22	30,00	2,22
III (2 x 40')	13,33	13,33	31,11	37,78	4,44
Average	**23,33**	**12,96**	**25,19**	**35,56**	**2,96**
Interval Tolerance	20 % ≤ PWI ≤ 30 %	10 % ≤ PWI ≤ 20 %	25 % ≤ PWI ≤ 35 %	25 % ≤ PWI ≤ 35 %	0 % ≤ PWI ≤ 5 %
Criteria	Fulfilled	Fulfilled	Fulfilled	Fulfilled	Fulfilled

Based on Table 5, all aspects of observed activity meet the ideal time tolerance criteria established, except the first indicator. So effectiveness based on the effectiveness of students in learning activities are met. This is because the minimum criteria that is 3 of 5 indicators are met with indicators 3 and 4 are met. Then based on the test results also obtained the average percentage of total positive responses of students to the devices and learning activities on the second trial of 90.26%. Therefore, students' responses are also fulfilled because students who respond positively to the components and learning implementation achieve ≥ 80%. Based on the above results obtained that the learning devices developed meet all the criteria of effectiveness set, namely mastery of learning outcomes in classical, student active activities and positive responses of students. Thus the learning device developed has met the effective criteria, so the device trials are stopped.

4.3. Description of Students Metacognition Ability Improvement

Based on the posttest result of students 'metacognition ability, the students' metacognition ability is improved on each indicator as shown in Table 6 below:

Table 6. Improvement of Metacognition Ability in Each Indicator

Indicator of Metacognition Ability	**Mean**			
	Trial I	**Trial II**	**Increase**	**%**
Determining and Developing Action Plans	2,51	2,88	0,36	14,34%
Organizing and Monitoring Action Plans	2,80	3,14	0,34	12,14%
Evaluate the actions that have been done	2,32	2,56	0,24	10,34%

Furthermore, the average value obtained in the classical test at 2.55 and II test of 2.86. Thus there is an increase in the average value of metacognition ability of students between trials of 0.31 or 12.16%. These results indicate that students' metacognition ability using problem-based learning devices developed improved from trial I to trial II. So it is concluded that learning-based learning devices that developed problems can improve students' metacognition ability.

V. Discussion

Learning devices developed in this research is learning device that is designed using problem based learning model where students will be trained to solve the problem by planning problem solving until reaching completion. According to Sinprakob&Songkram (2015), "Problem-based learning has an influence in teaching mathematics and improving students' understanding , as well as the ability to use concepts in real life (Padmavathy, 2013).

Furthermore, according to Wijnia et al (2014), the problem-based learning devices, therefore, according to Wijnia et al. (2014) which is developed is expected to train students to construct his knowledge so that it can become a habituation of students in solving problems independently. As Mamede et al (Du et al, 2016) says, "constructivist learning environments such as PBL are more demanding for learning that conventional linguistic skills and the need to self-regulate knowledge construction. The problem-based learning approach is also considered very important for the immature students in their thinking ability. Associated with the ability to think, students must also have the ability to be able to face the development of science and technology in the present. One of the thinking skills that can help students in solving problems that need to be improved is the ability of students' metacognition. As in Lianghuo& Yan's (2007) view, the fact that Singapore's mathematical syllabus also regulates this metacognition ability as one of the core components for the achievement of mathematical problem-solving abilities. So that metacognition abilities need to be improved in solving math problems. Metacognition as a form of cognition involving control of cognitive activity (Jayapraba, 2013; Aljaberi&Gheith, 2015).

According to Sart (2014), "Needless to say those individuals with greater metacognitive activity may be more likely to monitor and adapt their behaviors to create a more positive learning environment". The point is that students with greater metacognition activities will tend to monitor and adjust their behavior to create a positive learning environment. This statement is closely related to indicators of metacognition ability as well as an indicator of metacognition ability in this research that is determining and developing action plan, arranging or monitoring action plan, and evaluating problem solving process (NCREL, 2007).Sart (2014) also concluded that this problem-based activity puts students in a challenging situation so that they not only think of solutions to problems but also processes that allow them to arrive at those solutions. So in the development of this problem-based learning devices, researchers prepare learning that requires students to train their thinking awareness (metacognition) in solving problems through metacognition questions.

Problem-based learning is an option in developing students' metacognition abilities, this is because some research results show that metacognitive ability can be improved through problem-based learning (Downing et al, 2008; Amin, 2015). Application of learning PBL can train and develop students in metacognition on problem solving. As the results of this study indicate that the problem-based learning devices developed meet the valid, practical and effective criteria can improve students' metacognition ability. This is in line with several results which show that the development of problem-based learning devices can improve students' metacognition and other high-level thinking skills (Aufa et al, 2016; Syahputra& Surya, 2016; Mustafa et al., 2017; Surya &Syahputra, 2017) .

VI. Conclusion

Based on the results of analysis and discussion in this study, presented several conclusions as follows:

1. Learning device developed has met the valid criteria with the total validation value of the total is at the value of $4 \leq Va<5$. For practical criteria, it has fulfilled: i) the validator judgment states the problem-based learning devices developed is generally good and can be used easily, ii) the implementation of problem-based learning devices developed already meet the good category. For effective criteria, have fulfilled: i) achievement of classical completeness of metacognition ability of student already more than 85%, ii) activity of student during learning activity fulfill ideal time tolerance criterion specified, iii) positive student response to component of learning device and learning activity developed.
2. There is an increase in students 'metacognition ability derived from the average increase in total and the average increase for each indicator of students' metacognition ability from trial I to trial II.

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