The Development of Mathematics Learning Device with Metacognitive Approach Oriented to Mathematical Literacy and Mathematical Attitude of General High School Students

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Abstract. This study aims to determine the development of mathematic learning device with metacognitive approach which is oriented to the ability of mathematical literacy and mathematical attitude that is valid, practical and effective. Learning device development model refers to the Plomp Model which has 3 steps: preliminary stage, development or prototyping phase and assessment phase. The subject of the research is the students of grade VIIG SMPN 16 Yogyakarta in the second semester of academic year 2017/2018. The research data were obtained by validation sheet, teacher's assessment sheets, questionnaires of student assessment, learning enforcement observation sheet, mathematical literacy ability test, and questionnaires of students mathematical attitude. The product of this research is the lesson plans (RPP) and worksheets (LKS).The results indicate that learning device with metacognitive approach oriented to the ability of mathematical literacy and students' mathematical attitudes meet the validity based on expert validation results, practical based on teacher and student ratings, and effective requirements based on the achievement of KKM ≥75% and high category ≥75% mathematical attitude.

1. Introduction

There are five standard processes in mathematics learning according to NCTM[1], namely: problem solving, reasoning and proof, communication, connection, and representation (presentation). Ability that includes the five competencies above is the ability of mathematical literacy. The Program for International Student Assessment (PISA)[2] explains that mathematical literacy can be interpreted as a person's ability to formulate, use, and translate mathematics in various contexts. In this case, it includes the ability to apply mathematical reasoning, using concepts, procedures, facts, and device to describe, explain, and predict phenomena. A person is said to have a good level of mathematical literacy if he is able to analyze, reason, and communicate his knowledge and mathematical skills effectively, and able to solve and interpret mathematical solutions. The ability of mathematical literacy relates to how a student can apply a knowledge in real world problems or daily life, so that knowledge can be perceived directly by the students. Thus, the mathematical literacy ability of a student is more influenced by the student's own experience. Therefore, mathematics learning should be an effort in directing students to construct knowledge through the process. Knowing is not a product/result but a process that begins from experience, so that students should be given the widest possible opportunity to construct the knowledge they must possess. In addition, learning can be said to be meaningful if the information to be learned by the students is structured according to the cognitive structure that the student has so that the child can associate his new information with his or her cognitive structure[3].
In addition to the ability of mathematical literacy, there are psychological aspects that contribute to the success of a person in completing the task well, namely attitude. Gable[4] describes attitudes as the qualities one shows about how to feel and express emotions. Nitko and Brokhart[5] suggest that attitudes are the character of a person who describes their positive or negative feelings about a particular object, situation, institution, person or idea. Along with this, Popham[6] said that an important attitude to be improved because of student attitudes will determine how far students want to learn about something, such as learning mathematics. From the results of the evaluation and interviews with the subjects teachers obtained information that indeed in the learning of teachers have used RPP as a reference in teaching but RPP used is the duplication of RPP from other schools that the steps are still conventional learning, made not based on competence and school environment, so that learning in the school can not make students become active in the classroom, they are more waiting and expecting the help of teachers in solving every problem posed by the teacher. Though the activity of students in learning is the key to success in learning. To achieve these goals, in the process of learning mathematics need a corresponding approach in conveying learning materials. A properly implemented approach can help students understand the subject matter and achieve the learning objectives. Mathematics learning in schools still hold fast to teacher-centered learning[7]. That happens, because teachers are less accustomed to using student centered approaches, methods and models of learning.

Jensen[8] argues that meaning is not merely in the books. The meaning in the book should be expanded and enriched to its proper context. One way to make a subject taught to a meaningful student is to associate the subject with the student's daily experience or relate it to the circumstances in which the students grow and develop. The same opinion is also expressed by Johnson[7] that when a student can link the content of a subject, such as mathematics, sociology, or history with their own experience they find meaning, and the meaning gives them a reason to learn. This shows that in the learning activities teachers are required to have a strategy or approach that can be used to raise their students active in learning. One alternative approach to learning that is relevant enough to be used is a metacognitive approach. Kramarski & Mizrahi[9] found that students with high metacognition skills were more able to solve real-life problems and were able to communicate their reasoning results. Flavel[10][11] states metacognition is one's awareness of how he or she learns, the ability to judge difficulty in problems, 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 line with Costa [12] and Biryukov[13] who argued that metacognition is the ability to plan a strategy to produce the information needed to find a solution to a problem, to determine the strategic steps to be implemented, and to reflect and evaluate the productivity of its thinking ability.

Nitko & Brokhart[5] reveals that metacognition is defined as one's knowledge of cognitive processes and products or anything related to their consciousness. For example, a person is said to be using metacognition when he is able to realize that he is more difficult to study a certain material than any other material. The same thing Kuhn[14] disclosesthat a person will have metacognition skills if he has an awareness of metacognition knowledge and metacognition strategies used in accomplishing tasks. Metacognition skills in question are problem solving skills, decision-making skills, critical thinking skills, and creative thinking skills, while metacognition strategies referred to are self-planning, self-monitoring and self-evaluation. This implies that metacognitive skills are cognitive abilities that are considered most relevant to mathematical literacy. This is because the metacognitive thinking skills of degree two which requires a knowledge of his own knowledge and the knowledge of others. Flavel also explained that metacognition can be defined as one's knowledge of a person's cognitive process. In line with that, Moore[15] Livingston[16] states that metacognition is simply defined as “thinking about thinking”. Furthermore, Moore explained that the ability to think and learning ability is one example of metacognitive ability. This capability includes invisible thinking skills such as self-interrogation, self-checking, self-monitoring, and analyzing. Zimmerman[15] states that one of the metacognitive strategies considered quite effective is self-questioning strategies. North Central Regional Education Laboratory [17] provides an overview of metacognition. Metacognition
contains three basic elements, namely: (1) developing an action plan, (2) conducting monitoring, (3) evaluating the planning. Kramarski and Mevarech[18] also stated that metacognitive learning uses three sets of self-addressed metacognitive questions, which include: a) Comprehension questions (to reflect a problem before completing it), including reading and understanding problems, explaining the concepts relevant to the problem using their own language, and trying to understand the purpose of the concept, b) Strategic questions (to consider appropriate strategies for solving a task or problem), among other strategies that can be used to solve the problem, why the strategy can be used, and c) Connection questions (to train students to recognize the similarities or differences of problems that are being dealt with previously resolved), for example what is the difference/similarity of this problem with the previous problem.

These metacognitive questions are then written in the worksheet and in the teacher teaching manual (RPP). The learning procedure with metacognitive approach used adopted the Mayer model[19] by presenting the learning in three stages, namely the initial discussion phase, the self-employed stage of the student, and the stage of reflection and summary. Therefore, by developing metacognitive awareness, students are expected to be trained to always design the best strategy in choosing, remembering, re-recognizing, organizing the information it faces in solving the problem. Through the development of metacognition awareness, students are also expected to always monitor, control and evaluate what they have done. Mulyasa[20] argued that one of the things that need to be considered by teachers in implementing the Curriculum 2013 by taking into account individual student differences is how to modify and enrich the learning. Based on the existing problems it is deemed necessary to conduct research on development of learning device with metacognitive approach. Learning device developed include Learning Implementation Plan (RPP) and Student Worksheet (LKS). The questions in this study are: how is the validity, practicality, and effectiveness of mathematics learning device with metacognition approach oriented to the ability of junior high school students' literacy? The purpose of this research is to produce a valid, practical, and effective mathematics learning tool with metacognition approach oriented to the ability of mathematics literacy and mathematical attitude of junior high school students.

2. Method

This research includes the type of research and development (R & D). The development model used is the Plomp model consisting of: (1) Preliminary research; (2) Development or prototyping phase and; (3) Assessment phase. The subjects of the trial in this study were VIIG class students at SMP N 16 Yogyakarta academic year 2017/2018 with a total of 32 students. The reason researchers chose this school was because it was strategically located so that it was easier to carry out research.

2.1. Procedure of development

The development procedure begins with a preliminary research phase that includes context analysis, literature review, and the development of a conceptual or theoretical framework for research. At this stage, the researcher analyzes the issues that need to be resolved and the context in which the problem occurs. The analysis is based on information collected from relevant sources. The problems identified have become the basis for the need for development research to produce a product of teaching materials that is oriented to the ability of mathematical literacy and mathematical attitudes. At this stage a literature review of concepts and theories related to the metacognition approach, mathematical literacy skills, mathematical attitudes, instructional device, and other topics related to research problem solving are discussed. In addition, the development of a conceptual framework tailored to the solution of the problems obtained in the early stages of the study. The next stage is the stage of designing the initial product commonly called the prototype. The initial product designed is tailored to the problems acquired in the early stages. The learning device that will be developed is the implementation plan of learning and student activity sheet. The next procedure is the assessment stage that is the stage of concluding the feasibility of learning devices developed in accordance with expert
judgment and test results in the field. Each cycle consists of product testing, evaluation, and product revision. This cycle lasts until a product that meets quality standards is valid, practical, and effective.

2.2. Instrument and Data Collection Technique

Data collection techniques consist of test and non-test. The test consists of a math literacy skill test. While the non-test in the form of a questionnaire of students’ mathematical attitudes, validator assessments, teacher appraisals, student appraisals of instructional device, and observation sheet of learning implementation. The validation sheet is used to measure the validity of learning devices developed through expert judgment, which consists of an RPP validation sheet and a LKS validation sheet. Teacher assessment sheets, student assessment sheets, and instructional learning observation sheets are used to measure the practicality of learning device. The mathematical literacy test instrument is used to measure the effectiveness of the device. The achievement test instrument consists of a description item.

2.3. Data Analysis Technique

Data analysis technique is done to get the product of learning device with metacognition approach oriented to the ability of qualified mathematics literacy and fulfill the valid, practical and effective aspect. In this study the quality guidelines of validity and use the classification of interpretation of the assessment of the validity according to[21] as in Table.

| Interval Score | Criteria       |
|----------------|----------------|
| \( M_i + 1.5S_i < X \leq M_i + 3S_i \) | Very Good     |
| \( M_i + 0.5S_i < X < M_i + 1.5S_i \) | Good          |
| \( M_i - 0.5S_i < X < M_i + 0.5S_i \) | Enough        |
| \( M_i - 1.5S_i < X < M_i - 0.5S_i \) | Less Good     |
| \( M_i - 3S_i < X \leq M_i - 1.5S_i \) | Very Less     |

With,

Average Ideal (\( M_i \)) = \( \frac{\text{minimum score} + \text{maximum score}}{2} \)

Ideal Deviation Standard (\( S_i \)) = \( \frac{\text{maximum score} - \text{minimum score}}{6} \)

Ideal Maximum Score = \( \sum \text{item criteria} \times \text{highest score} \)

Ideal Minimum Score = \( \sum \text{item criteria} \times \text{lowest score} \)

Based on Table 1, we can determine the interval and learning devices developed as shown in Table 2.

| Interval Score | RPP     | LKS     | Criteria       |
|----------------|---------|---------|----------------|
| 116 < X ≤ 145  | 92 < X ≤ 115 | Very Valid |
| 96.67 < X ≤ 116 | 76.67 < X ≤ 92 | Valid     |
| 77.33 < X ≤ 96.67 | 61.33 < X ≤ 76.67 | Enough   |
| 58 < X ≤ 77.33  | 46 < X ≤ 61.33 | Less Valid |
| 29 < X ≤ 58    | 23 < X ≤ 46 | Very Less Valid |

Mathematics learning tools with metacognitive approach oriented to the ability of mathematical literacy is valid if it meets the criteria “Valid”. Analysis of the practicality of instructional devices aims to determine whether the developed device meets the practical criteria. The analysis was conducted on the results of the questionnaires filled with practicality of teachers and students and the observation sheet of the implementation of learning.
Table 3. The Interval of Practicality based on Teacher Questionnaire.

| Interval Score | Criteria       |
|----------------|----------------|
| RPP            | LKS            | Relatively         |
| 64 < X ≤ 80    | 52 < X ≤ 65    | 116 < X ≤ 145     | Very Practice     |
| 53 < X ≤ 64    | 43 < X ≤ 52    | 96 < X ≤ 116      | Practice          |
| 43 < X ≤ 53    | 35 < X ≤ 43    | 78 < X ≤ 96       | Enough            |
| 32 < X ≤ 43    | 26 < X ≤ 35    | 58 < X ≤ 78       | Less Practice     |
| 16 < X ≤ 32    | 13 < X ≤ 26    | 29 < X ≤ 58       | Very Less Practice|

Table 4. Practicality Criteria Learning Device Based on Student Assessment.

| Interval Score | Criteria       |
|----------------|----------------|
| LKS            |                |
| 40 < X ≤ 50    | Very Practice  |
| 33,33 < X ≤ 40 | Practice       |
| 26,67 < X ≤ 33,33 | Enough         |
| 20 < X ≤ 26,67 | Less Practice  |
| 10 < X ≤ 20    | Very Less Practice |

The quality of instructional devices is said to be practical when it meets the “Practical” criteria.

Data analysis to determine the effectiveness of instructional devices is measured from the results of mathematics literacy test. The test is done twice, i.e., pre-test and post-test using the same instrument. Furthermore, learning device are said to be effective if they meet the requirement that at least 75% of students in the class have reached ≥75. Determination of the value of mathematical literacy skills tests using the following provisions.

\[
\text{values obtained by students} = \frac{\text{scores obtained by students}}{\text{maximum score}} \times 100\%
\]

Meanwhile, to determine the percentage of students who reach KKM can use the following formula.

\[
\text{percentage of mastery} = \frac{\text{many students who achieve KKM}}{\text{many students entirely}} \times 100\%
\]

As for calculating the questionnaire results can use the following formula.

\[
\text{percentage} = \frac{\text{many students}}{\text{many students entirely}} \times 100\%
\]

3. Results

In the first stage found that the quality of mathematics learning is still low which further resulted in the activity and achievement of students' mathematics learning is still low and the unavailability of learning devices that provide opportunities for students to construct their own mathematical ideas. In the second stage after learning of mathematics such as analysis of the situation in the first stage, carried out a review of the activities of the theories that support to improve the quality of learning that are found in the first phase. From the results of this review, conducted an attempt to apply the Metacognition approach and develop a learning device that supports the characteristic applied learning approach. Learning device developed include Learning Implementation Plan (RPP) and the Student Worksheet (LKS) the standard of competence understand the concept of rectangles and triangles and determine its size. In the third stage, an activity is done to realize the design that has been made in the second stage so that the initial draft of learning device with Metacognition Approach in the form of RPP and LKS in the form of prototype 1 which furthermore need to be tested the validity, practicality and effectiveness in accordance with the criteria proposed by Nieven[22]. Not only there, at this stage also prepared a research instrument that will be used as a means of data collection and need to be tested its validity. In the fourth stage, tested the validity of learning devices that are still in the form of prototype 1 by 2 experts (validator) that is lecturer of Mathematics Education from Yogyakarta State University. Not only assessing the validity of learning device, validators also assess the validity of the
instruments to be used in the pilot activities. Based on the validation test of the learning device, then a small revision was made to obtain the learning device in the form of prototype 2 with the learning device criteria developed is valid. Likewise the instruments that will be used in the pilot activities have met the criteria worthy of use. After obtained learning device in the form of prototype 2, then conducted field trial. Field trials were conducted to determine the practicality and effectiveness of learning device developed. After the pilot activity, revision is made as necessary on prototype 2 so that it becomes the final prototype of instructional tool with Metacognition Approach for junior high school students grade VIIG. Implementation stage of learning device developed further submitted to the teacher concerned. Learning devices in the form of final prototype will be submitted to the school that became the testing ground.

Validity Learning Device

Learning device that have been developed, subsequently validated by a validator. Validation results for each expert can be seen in Table 5 below.

| No | Validator | RPP | LKS |
|----|-----------|-----|-----|
| 1  | 1         | 87  | 74  |
| 2  | 2         | 117 | 90  |
| Total |     | 204 | 164 |
| Average |     | 102 | 82  |
| criteria |     | Valid | Valid |

Based on the above table, it can be concluded: 1) the learning implementation plan is in valid and can be used with small revision, 2) student activity sheets are in valid category and can be used with small revision, 3) math literacy test is on category is valid and can be used with small revisions, 4) the questionnaire of mathematical attitude is in very valid category and can be used with small revisions. Once the device is validated expertly, then tested. The trial was conducted at nine VIID grade students of SMP N 16 Yogyakarta, which has a low, medium, high.

Practicality of Learning Devices

Practicality of RPP and LKS is known from the analysis of teacher assessment data and student assessment data. The data analysis practicality according to teacher assessment for each of the learning device can be seen in Table 6.

| No | Learning Device | Score | Interval Score | Criteria     |
|----|-----------------|-------|----------------|--------------|
| 1  | RPP             | 62    | $53 < X \leq 64$ | Very Practice|
| 2  | LKS             | 52    | $43 < X \leq 52$ |              |

Based on Table 6 above, it can be concluded that the RPP and LKS developed reach the practical criteria based on the teacher's assessment sheets. While in Table 7 it can be concluded that the developed LKS reached the practical criteria based on the questionnaires of student assessment. In addition to the data collection process implementation of learning to see that RPP and LKS that have been developed really have been done. Here the data observed during the learning process.

| No | LKS | Average | Interval Score | Criteria |
|----|-----|---------|----------------|----------|
| 36.125 | 33.33 < X \leq 40 | Practice |

Based on Table 6 above, it can be concluded that the RPP and LKS developed reach the practical criteria based on the teacher's assessment sheets. While in Table 7 it can be concluded that the developed LKS reached the practical criteria based on the questionnaires of student assessment. In addition to the data collection process implementation of learning to see that RPP and LKS that have been developed really have been done. Here the data observed during the learning process.

| Meeting | Observation Results |
|---------|---------------------|
| Teacher Activity | Student Activity |
Overall results of the assessment of teachers and students can be concluded that the learning device with developed metacognitive approach has met the criteria to be used practically. The results of the analysis of observations obtained enforceability of the learning process that results enforceability of the RPP is 87%. This indicates that the activities described in the RPP are almost complete. In addition, based on Table 8 learning device that have been developed have been implemented during the lesson.

Effectiveness of RPP and LKS

The effectiveness of the RPP and LKS seen from the results of mathematical literacy tests and poll result students' mathematical attitude. The results of the student test data analysis are summarized in Table 9 below.

| Table 9. Data Results The effectiveness of the RPP and LKS Based on Mathematical Literacy Proficiency Test |
|---------------------------------------------------------------|
| Results | Student | Percentage |
| Pass | 24 | 75% |
| No pass | 8 | 25% |

Based on Table 9 above, it can be seen that the achievement of mathematics literacy ability test has fulfilled the provision that has been set 75%, so it can be concluded that RPP and LKS developed have fulfilled the criterion “effective” based on mathematics literacy ability test result. The result of questionnaire of students' mathematical attitude is effective if at least 75% of students have reached the minimum category “high”. The results of the mathematical attitude analysis of the students are summarized in Table 10 below.

| Table 10. Data Result of Student Mathematical Attitude Questionnaire. |
|---------------------------------------------------------------|
| Interval Score | Criteria | Before Learning | After Learning |
|----------------|----------|----------------|---------------|
|                | Frequency | Percentage     | Frequency     | Percentage   |
| 116 < X ≤ 145  | 1        | 3%             | 3             | 9%           |
| 96.67 < X ≤ 116| 18       | 55%            | 28            | 85%          |
| 77.33 < X ≤ 96.67| 9        | 27%            | 1             | 3%           |
| 58 < X ≤ 77.33 | 4        | 12%            | 0             | 0%           |
| 29 < X ≤ 58    | 0        | 0%             | 0             | 0%           |

Based on Table 10 above on initial conditions before learning, there are still students who have low mathematical attitudes and some students have moderate mathematical attitudes. After learning with metacognition approach, no more students have low mathematical attitude. There is an increasing number of students who have high and very high category mathematical attitude that is 85% and 9%. It shows that learning device with metacognition approach is effective based on student's mathematical attitude questionnaire.

4. Discussion

Based on the assessment carried out by experts, the final product of the learning device that was developed with a metacognitive approach of class VII SMP has fulfilled valid criteria. Based on the results of field trials obtained the results of the assessment of the teacher and students on the learning tools that have been developed and have reached practical criteria. Practical criteria are met based on the assessment of teachers who practice learning tools directly. In addition, practical criteria are met
based on the assessments of students who take lessons directly in class. For observations of learning feasibility shows that the level of learning implementation is on practical criteria with an average percentage of 87%.

Based on field trials that have been carried out in general shows that the learning device produced has met the effective criteria. The first trial has shown effective criteria in terms of the results of the mathematics literacy ability test that has completed 75% of students have reached the KKM. Likewise for the second trial that has shown effective criteria in terms of mathematical attitudes, the results questionnaires of students mathematical attitude reached 94% including high criteria. This is in line with research conducted by[23] that metacognition strategies have a positive impact on students’ success in solving problems. Research conducted by[24] that students 'metacognition rates are based on students' mathematical literacy abilities consisting of students with high, medium and low mathematics scores. Likewise with research[25] that there is a positive relationship of metacognition awareness and cognitive skills.

5. Conclusion
Based on description above, the conclusions of this study are as follows.
1. Learning devices with Metacognitive Approach Oriented to Literacy Ability Mathematics and Mathematical Attitudes of junior high school students have met the valid criteria based on expert validation results.
2. Learning devices with Metacognitive Approach Oriented to Literacy Ability Mathematics and Mathematical Attitudes of junior high school students have met the practical criteria based on the results of teacher and student questionnaire.
3. Learning devices with Metacognitive Approach Oriented to Mathematical Literacy Ability Mathematics and Mathematical Attitude of junior high school students have fulfilled the effective criteria based on the percentage of students who reach KKM ≥75%. If the terms of the attitude of students' mathematical conclusion that students who achieve high criteria ≥75%.

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