

The Development of Mathematics Learning Material Based on Metacognitive Guidance Approach

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Abstract—To develop a learning that focus on students, we need an appropriate learning material. The purpose of the present study is to develop a learning material based on metacognitive guidance approach. The method of this research was research and development, which consists of four phases: define, design, develop and disseminate. In the define phase, we carried out front-end analysis to establish the basic problem on developing learning material based on metacognitive guidance approach. In the design phase, we organized design of learning material based on metacognitive guidance on the topic of circle. In the development phase, we conducted appraisal expert and developmental testing. Learning material was appraised by 2 experts. Furthermore, we conducted developmental testing in small group consisted of six grade VIII junior high school students in Lembang, West Java. The result of this study included a valid and effective learning material, such as student's worksheet, based on metacognitive guidance approach.

Keywords—learning material; metacognitive guidance approach; circle.

I. INTRODUCTION

Learning is a study process, built by teacher, to develop creativity in thinking and to improve student's ability in constructing their own knowledge. The learning process which gives an opportunity to students to constructing their knowledge, is an importance to consider, particularly on mathematics learning. Today, the process of mathematics learning still tend to teacher-oriented. As a consequence student become passive learner. Teacher as source of information gives as much as information, examples and tasks to students. This learning system demanded student to remember but not understand. Paul [7] stated, in traditional learning the tasks which is given in the class demanded student to do a certain symbolic procedure, but not for thinking. As a consequence students become automatons and not a critical and independent student.

Recently, the alteration of learning paradigm has changed the learning orientation toward student-centered. It's also asserted on curriculum 2013 that applied by Indonesia government. Following the alteration of learning paradigm, mathematics teacher is demanded to be more focus on learning development which can give opportunity to student become an active learner in constructing their own knowledge. It means, student knowledge is a result of learning process not as a direct present from teacher. As a subject of learning, student can construct their own knowledge by interaction to the objects and environment. Seeing that the diversity of intellectual and study style which have the impact to diversity of student's rapidity and ability in doing their tasks, so the learning based on constructive is very precise to be applied.

The alteration of paradigm has impact to the development of learning material. Beside teachers and students, the achievement of a learning process determined by what learning material used. Learning material is all kinds of material used by teacher or instructor for helping them in learning process [1]. Furthermore, [11] stated learning material as a set of material arranged systematically not only written form but also unwritten form so that can create an environment for helping student to study. The kinds of learning material based on the subject consist of two types, they are: (a) learning material which is designed intentionally for learning such as books, handouts, student worksheet, and module; (b) learning material which is not designed but it can be used for learning such as clipping, newspapers, film, advertisement or news. Based on the function, the classification of learning material divided into three groups, they are presentation, reference and independent learning material [6].

Learning material can assist teacher for leading student in finding concepts, developing skill and scientific attitude, prompting student's interest. On mathematics learning, math's

teacher have to be able to create a learning material which can be guided for student to find math's concepts and principles. It's asserted in government regulation on 2008, number 74 [4], teacher have to have pedagogy competences, one of them develops a learning material.

The result of observation and interview to the teachers was found some problem in mathematics learning. One of them related to learning material. Some of learning material such as book which used by teacher hadn't assisted student for constructing concepts. The book presented direct concept, so that students were not given opportunity to build their own knowledge. Another side, teacher got difficulties for creating constructive learning materials. Moreover, the availability of constructive learning material was too limited. Related to the lesson, students were still having difficulties on geometry, especially on circle subject. The result of interview to the students, they argued that mathematics as an abstract knowledge especially for geometry subject such as circle, space geometry.

In view of explained problems, needed to be developed learning material which can assist student to comprehend mathematics concepts. One of learning material is student worksheet. Student worksheet is one of printed learning material in sheet form that consist of hint, procedure for solving tasks. Student worksheet can be a guide for developing cognitive aspect and all learning aspects [12]. A constructive learning material can be developed by metacognitive guidance approach. Metacognitive guidance approach is one of learning approach based on constructivism theory. The principal characteristic of metacognitive guidance approach is utilizing a series of four self-addressed metacognitive questions. They are comprehension questions, connection questions, strategic questions, reflection questions. The comprehension questions were designed to prompt students thinking the problem/tasks before solving them. The connection questions were designed to prompt student focus on similarities and differences between the problem they work on and the problem that had already solved. The strategic questions were designed to prompt student to consider which strategy are appropriate for solving the given problem and for what reason. The reflection questions were designed to prompt students to reflect on their understanding and feeling during the solution process [3]. These questions can be guidance to student in understanding math's concepts and principles. The other side, the using of metacognitive question can train student to think critically and analytically.

Metacognitive guidance emphasizes the importance of giving student's opportunity for constructing mathematical knowledge that involved student's self-control. Metacognitive guidance based on IMPROVE's method: introducing the new concept, metacognitive questioning, practicing, reviewing and reducing difficulties, obtaining mastery, verification and enrichment [13]. Some prior studies related to metacognitive guidance were done by [2], [3], [5]. Nevertheless, there was no one of them who develop learning material formed student's worksheet based on metacognitive guidance for circle subject. Whereas, learning material based on metacognitive guidance has many utilities. One of them, learning material based on metacognitive guidance approach

emphasizes the importance of knowledge to what students are thinking and how to control their own thinking. In view of the importance of constructive learning material, the purposed of this research was to developed learning material formed student's worksheet based on metacognitive guidance for circle subject.

II. RESEARCH METHOD

The methodology of this research was research and development that suggested by Thiagarajan, Semmel and Semmel. Based on [10], model of research and development consist of four phases called model four D, they are: define, design, develop and disseminate. Nevertheless, the outcome of this research was up to develop phase because the outcome of learning material was not spread abroad to the institution. In the define phase, carried out front-end analysis to establish the basic problem on developing learning material based on metacognitive guidance approach. Observation and interview to the teacher and student were conducted by researcher for knowing learning obstacles on mathematical learning especially about learning material and the subject. The outcome of font-end analysis shown student got difficulties on circle subject and the constructive learning material on this subject is restricted. The yield of front-end analysis used for identifying, elaborating appropriate concepts to be developed based on metacognitive guidance approach.

Design phase, researcher organized learning material based on the problem in the define phase. The design focus on making constructive learning material based on metacognitive guidance on circle subject. The divisions of sub-subject on student worksheet design are: circle elements, the connection among circle elements, central angle and circumference angle, area of circle area, circumference of circle, length of arc and area of sector. In the develop phase, carried out expert appraisal and developmental testing on small group. Student's worksheet which was produced from design phase, assessed by 2 experts on mathematics. Furthermore, student's worksheet was tested on small group consist of 6 students grade VIII from one of secondary school in Lembang, West Java. Instrument of data collection consist of validation sheet, questionnaire for students, learning material (student's worksheet). The development of learning material based on metacognitive guidance in this research used stage: (1) introducing the new concept, (2) comprehension question, connection question, (3) strategic question, (4) reflection question, (5) practicing.

III. RESULTS AND DISCUSSION

The outcome of this research was development learning material "student's worksheet" based on metacognitive guidance approach in circle subject for student grade VIII. The appraisal to the student worksheet which was carried out by 2 experts on mathematics consist of content validity, language and presentation, illustration and table layout, figure, the utility of student worksheet. The validation yield of both expert, got total of average score 3,56 for all aspect. This score shown that the learning material "student's worksheet" based on metacognitive guidance had valid criterion. The score of judgment to the student's worksheet from each expert can be shown in the following Table I.

TABLE I. THE JUDGMENT RESULT OF TWO EXPERTS

| Assessed Aspects | Score Expert 1 | Score Expert 2 | Average | Total of Average |
|-------------------------------|----------------|----------------|---------|------------------|
| Content Validity | 3,6 | 3,7 | 3,65 | 3,56 |
| Language and Presentation | 3,3 | 3,2 | 3,25 | |
| Illustration and Table Layout | 3,4 | 3,6 | 3,5 | |
| Figure | 3,8 | 3,7 | 3,65 | |
| Utility | 3,7 | 3,8 | 3,75 | |


According to the suggestion of two experts, there were some revision to the student worksheet: (1) modification to the sentences on comprehension question and connection question so they can be clear; (2) changing the font face; (3) Altering the length of radius in table 1 and table 2 from 2 cm become 7 cm in length, so that student can be easy for determining the area and circumference of circle.

Developmental testing of student’s worksheet involves six secondary school students grade VIII. The aim of this testing was to see the effectiveness, response and suggestion from trainees. The result of testing shown the learning material “student’s worksheet” based on metacognitive guidance had effective criterion. The effectiveness was assessed from comprehension test in the end of student’s worksheet. The average score from the sixth student is 70. Based on the percentage, 80% student from trainee got score higher than 70. It means student’s worksheet based on metacognitive guidance was effective. The result of questionnaire shown student gave positive response to the student’s worksheet. Positive response on questionnaire means students argue that student’s worksheet is readable and understandable from the sentence on the question and activities, attractive from picture and table and easier student to understand the mathematics concept on circle subject.

There were some revision from student’s worksheet based on metacognitive guidance approach especially about the sentences of problem and comprehension question. The instance of problem and comprehension question before alteration shown in the following figure 1.

Problem

Vera makes a paper fan such as picture. The radius of paper fan is 14 cm in length and the central angle is 120° . How wide the surface area of paper fan in the picture? Could you estimate the length of arc from paper fan in the picture?



a. What is information known from illustration?


b. What are the problems that have to be solved?

Fig. 1. Problem and comprehension questions before the alteration

The final result after assessed by two expert, shown in the following figure 2.

Problem 1

Vera makes a paper fan such as picture 1. The radius of paper fan is 14 cm in length and the central angle is 120° . How wide the surface area of paper fan in the picture 1? Could you estimate the length of arc from paper fan in the picture 1?



a. What is information known from problem 1?

b. What are the problems that have to be solved based on problem 1?

Fig 2. Problem and comprehension question after the alteration

The principle characteristic of metacognitive guidance approach is the using of metacognitive question. One of them is comprehension question, this question on student worksheet shown on figure 2 part (a) and (b). For answering comprehension question part (a) and (b) student had to read problem 1, then they had to describe the problem in their own world. In fact, these question guide student to optimize their thinking. This premise asserted [3], the comprehension question is designed to prompt student thinking the problem before solving them. For answering comprehension question, student had to read problem and describe the task in their own word. This question could establish student prior knowledge before learning the concept farther.

Student’s worksheet based on metacognitive guidance approach also used connection question. This question is designed to prompt student to focus on similarities and differences between problem they work on and the problem they had already solved. On the following figure 3, question 5 and question 6 used as guidance to student for seeing the connection between central angle and entire central angle. On this case student had to open their memory about central angle and entire central angle, so that they could built the connection both of them.

5. Look at back to the table 1 that has been filled. How is the connection between central angle and entire central angle?

6. How is the connection between area of a circle and area of sector AOB? Conversely, how is the connection between area of sector AOB and area of a circle? Explain.

Fig 3. Connection Question

For the sixth question student had to memorize the previous knowledge about the concept of circle area and the concept of circle circumference. Then, they have to establish the similarities and differences for constructing the relation from both of them. In the fact, connection question is useful for student for establish new knowledge. The using of connection question in this student's worksheet related to cognitive theory from Piaget. Piaget theory assumed that in learning process student underwent three process, they are assimilation, accommodations and adaptation consist of equilibrium and disequilibrium [9]. The process of assimilation happens when student receive new information. After that the new information will be modified by cognitive structure so that the old information and new information integrated.

On the student's worksheet used strategic question for assisting student to assess the appropriate strategy in solving problem. Mavarech and Kramarski [13] asserted that in addressing the strategic questions, students had to describe *what* then *why* and *how*. The other principle characteristic of metacognitive guidance approach on student's worksheet is using reflection question. This question assists student for seeing back, reflecting and assessing their work that had been done. The example of reflection question can be shown in the following figure 4.

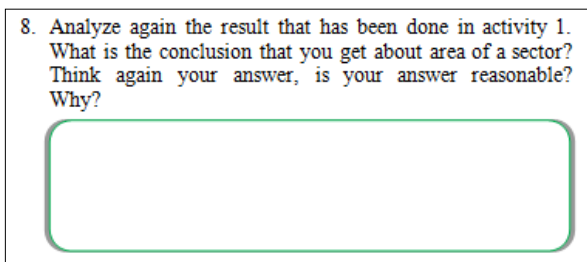


Fig 4. Reflection Question

On the figure 4, student asked to analysis the activity 1 that had been done. This question leads student to draw conclusion by seeing the appropriate reason. When students often asked reflection question to themselves, this question can train student to take decision with reasonable reason. As asserted by [8], before you make final judgment about an argument, you must know whether the reasons are acceptable or not.

In the final phase of metacognitive guidance on this learning material, students worked two kinds of problem or question that related to concept that had already found. This question or problem given in practicing phase, the purpose of this question was to see whether students comprehend the concepts or not.

IV. CONCLUSION

The outcome of this research included a learning material based on metacognitive guidance approach which was valid and effective. The learning material had valid criterion based on the appraised of two experts. Furthermore, the result of developmental testing in small group shown the learning material based on metacognitive guidance was effective. As a final result of this research got a learning material "student's worksheet" based on metacognitive guidance approach for circle subject that was valid and effective.

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