

Development of Learning Materials Based on Problem Based Learning to Improve Students Problem Solving Ability

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Abstract—Problem Based Learning is a set of teaching models that use problems as a focus for developing problem solving skill. The purpose of this study is the produce qualified learning materials which is developed based on Problem Based Learning and analyze the improvement of students mathematic problem solving ability which is learned using Problem Based Learning materials. This research is a development research using the Thiagarajan 4-D development model. Trials of learning materials based on Problem Based Learning were conducted three times to obtain quality devices. Based on the analysis, Problem Based Learning based learning materials that are taught have good quality at the stage of dissemination and the ability to solve mathematical problems learned by using Problem Based Learning devices is increased during the disseminate stage. The results of the analysis of the data obtained indicate that Problem based Learning materials can improve mathematical problem solving ability.

Keywords— 4-D model, development of learning materials, problem based learning, mathematical problem solving ability

I. INTRODUCTION

In the world of education, mathematics is one of the subjects that plays an important role in helping develop the potential of students. Studying mathematics can help students to think and study things logically and systematically. This is consistent with what [1] mathematics is a method of logical thinking. Mathematics is a condition with values that can shape the personality and character needed to face the challenges of a competitive age and demand professionalism. This is in line with what [2] "Mathematics is a science and intuition that strengthens belief, which is very important and useful in everyday life and in supporting the development of human resources and also helps develop logical, planned, objective, objective and rational thinking patterns and is very competent. , So everyone needs to learn".

[3] "Problem solving has a special importance in study of mathematics. A primary goal of mathematics teaching and learning is development the ability to solve a wide variety of complex mathematics problems".But the facts show that students' mathematical problem solving abilities are still low. The low level of mathematical problem solving abilities of students was also found in this study. Based on the results of

observations that have been made, it is found that students' problem solving abilities are classified as low.

Here, students immediately develop mathematical models and apply strategies to solve problems. But in terms of solving problems students are still not thorough in calculations. Then from the results of interviews with teachers it is known that the teacher is not accustomed to solving problems by writing what is known in the problem. However, NCTM also revealed the first indicator of problem solving ability was identifying the elements that were known, which were asked and the adequacy of the elements needed. Thus to train students to understand the problem, the teacher must train students to identify the known elements in the problem.

Given the importance of mathematical problem solving skills that students must master after learning mathematics and facts that show students 'low mathematical problem-solving abilities, steps need to be taken to improve students' mathematical problem solving abilities.

To solve the above problems, teachers are required to be able to find and find a way that is able to optimize problem solving ability. One of them is by reforming the learning materials and student learning strategies.. According to [4] "Instructional materials play a very important role in teh teaching and learning process". The importance of device learning in learning activities is also supported by research by Nwike & [5] "From the findings the study, it can be seen that students taught with instructional materials performed better than those who taught without. It was therefore recommended that instructional materials be used in teaching because it has positive impact on student' performance".

Learning materials will facilitate students to be actively involved in developing their potential. The quality of the development of learning materials according to [6] includes "validity, practically and effectiveness". "The strategy of teaching good students plays an important role in addition to mastering the teacher about the content of mathematics" [7]. One strategy by choosing a learning model that has the opportunity to improve problem solving skills is Problem Based Learning.

II. THEORETICAL FRAMEWORK

A. Mathematical Problem Solving Ability

Problem solving abilities according to [8] OECD are: *Problem-solving skills, i.e. the capacity of students to understand problems situated in novel and cross-curricular settings, to identify relevant information or constraints, to represent possible alternatives or solution paths, to develop solution strategies, and to solve problems and communicate the solutions.*

[8] mentions that there are 4 standards in solving problems “*Built new mathematical knowledge through problem solving, solve problem that arise in mathematics and in other contexts, apply and adapt a variety of appropriate strategies to solve problems and monitor and reflect on the process of mathematical problem solving*”. To solve a problem, a problem solver can use the strategy or steps formulated by [9] namely:

First, we have to understand the problem; we have to see clearly what is required. Second, we have to see how various items are connected, how the unknown is linked to the data, in order to obtain the idea of solution, to make a plan. Third, we carry out our plan. Fourth, we look back at the completed solution, we review and discuss it.

Then in this study, the problem solving process was used through three stages, namely “Understanding the problem, solving the problem and answering the problem” adapted from Polya's three problem solving processes. The use of this problem solving process is due to “the Charles, Lester and O’Daffer scale and its modified forms are easy to use” an advantage of such a scale is that a teacher may focus on only one of the stages [10]. As for the modified scale:

TABLE 1. SCALE ANALYSIS FOR PROBLEM SOLVING INDICATORS

ANALYTIC SCALE FOR PROBLEM SOLVING
<p>Understanding the Problem</p> <p>0 – No attempt</p> <p>1 – Completely misinterprets the problem</p> <p>2 – Misinterprets major part of the problem</p> <p>3 – Misinterprets minor part of the problem</p> <p>4 – Complete understanding of the problem</p>
<p>Solving the Problem</p> <p>0 – No attempt</p> <p>1 – Totally inappropriate plan</p> <p>2 – Partially correct procedure but with major fault</p> <p>3 – Substantially correct procedure with minor omission or procedural error</p> <p>4 – A plan that could lead to a correct solution with no arithmetic errors</p>
<p>Answering the Problem</p> <p>0 – No answer or wrong answer based upon an inappropriate plan</p> <p>1 – copying error , computational error, partial answer for problem with multiple answer; no answer statement; answer labeled incorrectly</p>

2 – Correct solution

From the descriptions above, it can be concluded that mathematical problem solving ability is the ability possessed by students in solving mathematical problems in applying the knowledge previously obtained into new situations by paying attention to the process of finding answers based on the steps of problem solving namely understanding the problem, make a settlement plan and solve the problem.

B. Problem Based Learning

According to [11], Learning based on problems is the interaction between stimulus and response, is the relationship between the two directions of learning and the environment. The environment provides input to students in the form of assistance and problems, while the brain's nervous system functions to interpret the aid effectively so that the problems faced can be investigated, assessed, and analyzed, and the solutions are sought well. Student experience gained from the environment will make him material and material in order to gain understanding and can be used as guidelines and learning goals.

[12] "Problem-based learning is a set of teaching models that use problems as a focus for developing problem solving skills". In line with that, [13] "Problems in PBM are problems that are ill-structure or contextual and engaging, thus stimulating students to ask questions from various perspectives". From the above descriptions it can be concluded that the Problem Based Learning model is a learning model that begins with contextual problems and involves students in the problem solving process.

C. Learning Materials

[14] “Instructional materials are essential and significant tools needed for teaching and learning of school subjects to promote teachers’ efficiency and improve students’ performance”. Based on the description above, the learning materials can be interpreted as a number of materials or tools that students and teachers will use in the learning process. Furthermore, the development of learning materials is a process carried out to produce a series of learning materials used by teachers and students in the learning process in the classroom. In this study, the learning tools developed were teacher books, student books, student worksheets, tests of mathematical problem solving abilities and student self-efficacy.

III. RESEARCH METHOD

This research is development research. This study uses the development model of Thiagarajan, et al which is also often referred to as 4-D, covering four stages, namely defining, designing, developing and disseminating. This research was conducted at SMK Swasta Ar-Rahman Medan,

which is one of the high schools in Medan, North Sumatra, Indonesia. The subjects in this study were students of class XI TKJ 1, XI TKJ 2, XI TKJ 3 and XI AK.

To analyze the improvement of students' mathematical problem solving abilities, data were obtained from the results of students' pre-test and post-test. Improving students' mathematical problem solving skills can be obtained from the t-test related to the sample, as follows:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2} - 2r\left(\frac{S_1}{\sqrt{n_1}}\right)\left(\frac{S_2}{\sqrt{n_2}}\right)}}$$

IV. DATA ANALYSIS, RESULT AND DISCUSS

The Description of Learning Materials Development Stages

In this development research, problem-based learning-based learning materials have met the quality of effective learning tools in trial II and can be applied at the deployment stage which is tested for effectiveness before being disseminated. The final draft has been obtained at the disseminate stage. The results of the development of learning materials using the Thiagarajan 4-D model are explained as follows.

Stage 1-Define

This stage includes five main steps, namely: (a) initial preliminary analysis; (b) student analysis; (c) concept analysis; (d) task analysis; and (e) formulation of learning objectives. Based on observations of learning materials, there are some weaknesses in the learning device used by the teacher, because the teacher has not developed according to the characteristics of students, such as in the teacher's book and books students have not provided contextual problems, and the teacher does not use student worksheets as support for learning activities. Furthermore, in the learning process the teacher still uses direct learning during the learning process, and the teacher is also not accustomed to giving motivation to students in solving problems given. This results in students appearing less active during learning and having good self-efficacy.

Stage 2-Design

At this stage the initial draft lesson plan was produced for 3 meetings, teacher books, student books, student worksheets and tests of mathematical problem solving ability based on the specifications of the learning objectives and indicators of ability measured, the tests developed are adjusted to the cognitive level of the students. All results at this design stage are called draft I

Stage 3-Develop

At this stage, the draft I which has been revised by experts is tested on the class outside the research subject. The aim is to see weaknesses in draft I so that it can be revised and refine the learning material developed. Expert validation results in the form of content validity assessment which shows that all learning tools meet valid criteria, with the total average value of the validation teacher books being 4.61, 4.55 student books, and 4.54 student worksheets. All items test students' mathematical problem solving ability meet valid criteria and can be used. Instrument reliability is used to determine test results. After calculation, the reliability of the math problem solving ability is 0.838 (high category).

After the learning device developed has met the validity criteria, the learning device in the form of draft II is tested in the subject and place of research, hereinafter referred to as the trial I. Based on the results of the first trial data analysis, it was found that the learning tools developed did not meet all the effective criteria, so that improvements were needed to produce learning materials that met all the effective criteria set. The revision is based on the findings of the weaknesses of the learning device in the first trial, which is that the sentence sentences in the student book are less understood by students. After the revision was completed, the second trial was conducted to determine the effectiveness of the learning device, as well as improving the mathematical problem solving ability.

Stage 4-Disseminate

The development of learning materials reaches the final stage if it has obtained positive values from experts and through development tests. The learning materials are then package distributed and determined for a wider scale. But in this study the disseminate stage was not carried out, so the fourth stage was not explained.

Result of Trial I

From the results of the trial data analysis I, it is known that the learning device developed has not been effective, because there are still a number of indicators of effectiveness that have not been achieved, namely in the first trial the percentage of classical completeness achieved was 68.75%, which means that it has not met the criteria for achieving mastery in a classical manner, other than that it is only questions 1) a, 1) b and item 2) a course that reaches the criteria for achieving a learning goal of at least 75%. While the indicators of effectiveness that have been fulfilled in the trial I are the achievement of learning time, namely the learning time used during the trial I is the same as ordinary learning and student responses, namely students respond positively to the components of the learning system Problem Based Learning developed. Based on the results of the analysis from the trial I, it is known that the learning device developed has not met all the effective criteria, this is caused

by several factors, among others, from the teaching and learning process that has not been able to be carried out optimally. Furthermore, other factors that also affect failure to meet effective criteria are the learning materials used, so that it needs to be revised to several components in the hope that Problem Based Learning materials can improve students' and students' mathematical problem-solving ability.

Result of Trial II

After conducting the first trial on the second draft, further improvements were made to produce a learning device that fulfilled all the effective criteria set. The results of the revision in the draft II produced a draft III which was then tested on class XI TKJ 2 students.

The development of learning materials reaches the final stage if it has obtained positive values from experts and through development tests. After learning materials are developed, they have met the effectiveness criteria through trials. Based on the results of data analysis, learning developed materials developed Learning tools developed based on Problem Based Learning for class XI were obtained during distribution. The learning materials has met the criteria of valid, practical and effective. This is indicated by (1) The implementation of learning by using the device is in a good category and the level of implementation is 88.66; (2) Classical completeness is achieved where students complete 86.67%; (3) Achieved learning objectives where students who have at least moderate problem-solving abilities are 80%; (4) A total of 96.67% of students have a positive response to the components of the learning device; (5) The time used in the application of learning materials based on Problem Based Learning, does not exceed ordinary learning. The students' mathematical problem solving abilities learned by using learning materials based on Problem Based Learning increased during the dissemination stage with an average of 81.50. Thus, the problem-based learning materials developed can already be deployed to a wider stage.

DISCUSSION

Development of Problem Based Learning materials in this study was carried out in accordance with the 4-D development model procedure. Learning materials that are developed must be of good quality, that is fulfilling valid, practical and effective criteria [21]. Based on the results of the posttest II trial analysis it was found that students' mathematical problem solving abilities met these effective criteria because the materials and problems in the student book and activity sheets were developed according to the characteristics and environment of students. This is in accordance with Ausubel's learning theory which states that meaningful learning is the process of connecting new information or material to concepts that already exist in one's cognitive structure [11] Research related to problem-based

learning (PBL) conducted by [20] there is an increase in problem solving abilities taught by problem-based learning models in test I 0.312 and in trial II 0.441.

Student learning completeness is also influenced by the learning model used in the learning process, which is a problem-based learning model that makes students interested in learning and actively involved in the learning process. The same thing stated by [19] "Improving the ability of mathematical problem solving students who receive the application of problem-based learning models is better than students who accept conventional learning". Then [15] "problem solving abilities of students using a problem-based learning model are better than conventional learning". This is also supported by the results of [6] "The results of the study show that the application of problem-based learning models can improve students' problem solving and self-efficacy skills". Based on the results of research and support from the previous research above, it can be seen that the problem-based learning tools developed can help students in learning.

Naturally, if an increase in problem solving skills is taught mathematics through problem-based learning, because problem-based learning uses contextual problems so that students are easier to understand and able to develop knowledge gained from personal experience. This is supported by the theory of [16] which emphasizes social experience and skills, where the learning process will occur if children work, handle tasks that have not been studied, but the task is still within their reach so that children can solve problems by developing self-efficacy. Furthermore, [17] added that social interaction with other people both teachers and peers can build new ideas and improve students' intellectual development. Student learning completeness is also influenced by learning models used in problem-based learning processes that make students interested in learning and actively involved in the learning process [18]. This is in line with the results of the research of [18] learning materials developed are effective in terms of student learning completeness. The category of learning outcomes effectiveness is effective if many students achieve 85% classical completeness. With each indicator increasing at the end of the meeting in learning. [3] problem solving has important meaning in mathematics learning. The main purpose of learning mathematics is to develop complex mathematical problem solving skills. Therefore, in mathematics learning the ability to solve problems is very important.

V. CONCLUSION

Based on the results of analysis and discussion in this study, it can be concluded that learning materials based on Problem Based Learning have met the criteria of quality (valid, practical and effective) and the ability to solve mathematical problems has increased. This study shows that learning materials based on Problem Based Learning are important things that need to be considered in an effort to

maximize students' mathematics learning achievements. Thus, it is expected that mathematics teachers can use this learning model by making quality materials in mathematics learning at school.

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