The Development Mathematics Device with Problem Based Learning Model to Increase Mathematical Problem Solving Ability

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Abstract. The issue of students’ difficulties in Mathematical problem solving should be resolved. One of the ways to overcome that problem is developing an appropriate learning tools. This case is expected to increase students’ ability in solving Mathematical problem. The type of this research was development research and used plom model in it. This research was consisted of three stages. They were prelimenary, development, and evaluation analysis. The result of this research was practical and effective Mathematics learning device. The analysis validation of lesson plan and students’ worksheet stated that they were valid. Besides, learning device was practical based on the result of analysis. The result was proven at interview guidelines, teacher’s response questionnaire, students’ response questionnaire and observation sheet in implementation of learning. The result of average percentage of practical score, teacher’s response got 88.99 %. Meanwhile, students’ response was 85.12 %. The result of practicality of learning device was strongly practical categories. Besides, learning device was effective to increase the ability of students in solving problem, especially at grade one of senior high school in Indonesia. Learning device that was developed had effective criteria. The result of students’ competency who are able to solve the Mathematic problem was 63.63 %. Their score were above Minimum Criteria of Mastery Learning.

1. Introduction
Education is an effort which aimed to guide someone to develop his/her personality and ability based on the applicable values in society. Education determines the progress of a world. It means, the more developed a country, it automatically influences to its education. One of the subjects that is always taught in education is mathematics. Mathematics is a science that has a role in buttressing science and technology. Mathematics is a means to thinking scientific as a way to develop the exact sciences, engineering, social and also other disciplines. Moreover, Mathematics also develops the mindset of students. It is useful to solve the students’ problem. Math equips students to face the problem that they face. It is stated at Ministrial Regulation of Education and Culture Number 59 [1]. Problem solving is the process that is used to solve a problem [2]. Problem solving in mathematics includes the process of finding answers from questions. It requires the procedures or steps that are not usual. It is also not included in the form of the texts, non-routine puzzles and situations in a real life [3]. Problem solving skills should be mastered by students in learning mathematics. Problem solving ability is the student's skill in finding solutions of a problem given. However, it is difficult to be achieved by students. In fact, the students' problem solving ability is low. This ability is observed from the research that was
conducted by K. Darma, Cut Yuniza Eviyanti, Himatul Ulya, Tina Sri Sumartini and Sandro J. Simamora [4-8]. The low problem-solving skills can also be viewed from the results of preliminary research that had been conducted toward students at grade X of Senior High School in several schools. One of the observational activities is giving a test about math problem solving. The ability that had been given is a simple narrative problem. Based on the assessment that was conducted, there were no students who were able to answer the test correctly. It was caused by the students who had not been trained in solving problems.

Some students didn’t do the instruction of the test. They got wrong in identifying the data sufficiency to solve the problem. So that, they were not able to complete the problem-solving of the test. Based on the result, it can be concluded that students’ ability in solving math problem was still low. It was caused by the students’ interest. They were lack interested in Math. They assumed that mathematics had many formulas and was not important. They didn’t comprehend the advantages of math in their lives. They complained about book inventory in the library. There was only a textbook with a publisher. Moreover, it had limited amount.

Based on the results of the interviews. It was obtained that teachers had not developed teaching materials (modules, students’ worksheet, handouts, teacher’s quote) which could help students in learning process. The teacher explained that was caused of limited time. The teacher was more focused on textbooks in school. In addition, the designing of learning device was less than optimal. The aim achievement Math can not be apart of learning device [9]. The learning device that are used are the Student Worksheet and lesson plan. The lesson plan that was suitable with 2013 curriculum wasn’t be designed optimally. The teacher had not focused the learning process on mathematical problems related to problems in daily life. In addition to the lesson plans. The teachers had not developed learning media yet. For instance, the Students’ Worksheet.

The low problem solving skills can be done by applying a model. This way had four effects to gain knowledge, improve problem solving skills, think critically and think creatively. Therefore, it needed the improvements toward learning device. A process is needed to design problem-based learning experiences for students [10]. One of them is by developing a learning model of Problem Based Learning (PBL). It is a learning model based on the constructivism and accommodates the students’ involvement in learning solving contextual problems [11]. PBL discusses and solves authentic problems. PBL is designed by giving initial problems that should be solved by students. So that, if the students are trained to solve the problems, it can equip them to answer the challenge of time. This model has a effect to the students to develop analytical, systematic, creative and logical thinking skills. Therefore, the students are able to find alternative problem solving.

The Problem Based Learning lets the students to think freely to find concepts and try to solve the problems related to the material given. This is a learning model that uses a real life as a context for the students to solve the problems that were obtained by teachers and students. The PBL encourages students in arrange their own knowledge, develop a higher skills, train students ‘independence, and increase students’ self-confidence. In this model, the teacher doesn’t only stand in front of the class and give students steps to solve problems, but also acts as a facilitator in a discussion. The teacher helps students to realize the importance of learning. Therefore, they are motivated to solve the problems. PBL-based learning device apply an environmental problems around the students. Students are guided to be able to determine the solution of these problems. Based on the description above, the researcher conducted the research with entitle The Development Mathematics Device with Problem Based Learning Model to Increase Mathematical Problem Solving Ability in Mathematics Subjects at Class one of senior high school.

The identification of problem above explains that students’ ability in problem solving was low, teacher’s lesson plan was not optimal yet and the teacher didn’t develop some appropriate students’ worksheet yet based on students character.

Based on the background of the problem above, this research problem formulation was “How did the ways to develop students’ mathematical problem solving which was practical and effective
through learning device on Problem Based Learning (PBL) in Mathematics Subjects at Class X Senior High School?"

The purpose of the research referred to the formulation of the problem above. It produced learning device based on Problem Based Learning (PBL) to improve students’ mathematical problem solving which was practical and effective in mathematics subject at class X Senior High School.

Product Specifications that had been developed are PBL-based learning device namely Lesson Plan and Students’ Worksheet for students class X at even semester compulsory mathematics subjects. PBL-based learning device was developed by using communicative language and according to curikulum 2013.

2. Method
The type of this research was development research (design and development research). Development research is a research that is used to produce certain products and test the effectiveness of the products [12]. This research would produce practical and effective learning device. This research was focus on producing products on Lesson Plan and Students’ Worksheet based on PBL models in high school grade X even semester. The development model used the Plomp model. Plomp divides the development phase into three stages, the preliminary research phase, prototyping phase, and assessment phase [13]. Preliminary research phase aims to see what needs are needed. This phase carried out the analysis of problems and needs, analysis of student characteristics, curriculum analysis and concept analysis. Prototyping phase or prototype development phase is designing and developing learning device gradually by using formative evaluation. Formative evaluation is useful for improving the prototype that was developed. The formative evaluation carried out to determine the outcome of development is the formative evaluation of Tessmer [14]. Formative evaluation is carried out through several stages in each prototype, namely the stages of developing prototype I, developing prototype II, prototype III and prototype IV. Whereas, in the assessment stage, the study was conducted by observing the learning process and the students 'competencies which included the students' problem solving abilities while using the learning tools. The activity was focused on evaluating whether PBL model-based mathematics learning device could be used to achieve the effective goals in improving the quality and student learning achievement.

The subjects of this research development were students at grade X students of senior high school and 1 Mathematic’s teacher at senior high school. The type of data was qualitative data and quantitative data. Qualitative data was obtained from discussions and interviews with teachers and students in the preliminary stage and evaluations at the prototype preparation stage. Quantitative data was obtained from the results of the validity and practicality questionnaires, observation sheets, and mathematical test of problem solving abilities. It was useful for measuring student competencies after using learning tools that had been developed. Data collection was done by using instruments. The instrument was an aid in data collection. The instruments used are instruments of validity, practicality and effectiveness.

3. Result and Discussion
Based on the results analysis of preliminary investigation (Preliminary research Phase), mathematics learning device in the form of Lesson Plan and Students’ Worksheet were designed and developed based on PBL. At the development stage, the design of learning device was referred to the standard rules of learning devices and adjusted to the characteristics of learning device based on PBL models. After getting the results of Lesson Plan and Students’ Worksheet models, On the development of device, self evaluation and expert review were conducted. Based on the validator's suggestions, a revision of the Lesson Plan and Students’ Worksheet was carried out in order to obtain a valid learning device. The results of the validator showed that the average validity index of the Lesson Plan based on the PBL model was 86.78%. It meant very valid criteria. Whereas, the results of the validation of the Students Worksheet developed that was developed in content, presentation, linguistic and graphic skills had an average of 87%. The criteria was strongly valid.
After the validation process by the experts was completed, it was continued by revising prototype 1. The results of the revision of prototype 1 were called prototype 2. The activities carried out by prototype 2 were testing the practicality of the learning device. Practicality is a quality that enables to carry out a function of the instrument on data collection this is based on the time taken to set, simple scoring, interpretation and affordable costs. The practicality test was aimed to find out the advantages, effectivity and efficiency of using Worksheet by teachers and students. The results practicality of the PBL learning model was evaluated through one to one evaluation, small small group and field test.

The development of prototype 2 was conducted with a one to one evaluation. One to one evaluation was aimed to ask for the product that was developed. This individual evaluation was conducted by asking 3 students from class X social sciences had different abilities. They were a student who had high ability, average ability and low ability. One-on-one tests were done around six times. After it was finished, the students were interviewed about Worksheet that had been provided. The instrument was an interview guide with students. The results of interviews can be concluded that students were interested to the Worksheet by using PBL models in learning mathematics.

Afterwards, the Worksheet was revised and the results of the revision were called prototype 3. The development of prototype 3 was conducted with a small group evaluation. It was done by asking 6 students from class X social sciences who had different abilities. Two students who had high-ability, two students who had medium-ability and two students who were in low-ability. Students in a small group test was differ with students in the one-on-one test. Practicality testing was carried out by using interview guide, student questionnaires and lesson plan implementation sheets. The practicality data of the equipment was obtained from the results of the students' questionnaire responses and implementation of lesson plan at the small group test can be viewed in Table 1:

| Questionnaire                             | Percentage of Practicality | Category         |
|-------------------------------------------|----------------------------|------------------|
| Students’ response                        | 86.60 %                    | Strongly Practical |
| The implementation of lesson plan sheet   | 83 %                       | Strongly Practical |
| Final Average                             | 84.8 %                     | Strongly Practical |

Students' responses were obtained through questionnaire after learning process of PBL model. Questionnaire was given to students of class X social sciences. The results of the questionnaire responses of students to the PBL model were included in Strongly practical that got score 86.60%. Furthermore, the questionnaire practicality of the device by the teacher was 83%. It was strongly practical category. Thus, the final average practicality of the device was 84.8% which was included in strongly practical category.

The results of small group test were called prototype 4. The development of prototype 4 was conducted by field tests. This test was done in class X natural sciences. Practicality testing was conducted by using interview guide instruments, students’ questionnaires, lesson plan implementation sheets and teacher response questionnaires. The practicality data of the device at the stage of the field test can be viewed in Table 2:
Table 2. The Result of the Practicality Questionnaire on field test

| Questionnaire                  | Percentages of Practicality | Category          |
|-------------------------------|----------------------------|-------------------|
| Students’ response            | 85.12%                     | Strongly Practical|
| The implementation of lesson plan sheet | 85%                     | Strongly Practical|
| Teacher response              | 88.99%                     | Strongly Practical|
| Final average                 | 86.37%                     | Strongly Practical|

Teacher and students’ responses were obtained through filling out the questionnaire responses that were given after learning process of PBL model. Questionnaires was given to students and teacher at grade X natural sciences. The results of the questionnaire responses were included in strongly practical category. The score was 85.12%. In another side, the teacher questionnaire was also included in strongly practical category. It had score around 88.99%. Furthermore, the practicality sheet of the teachers’ device was 85%. It was strongly practical category. Thus, the final average practicality of the device was 84.8%. It means that the kind of its category was strongly practical. Based on these three stages, it can be concluded that PBL-based learning tools are practical.

After conducting the field tests the next step was doing the effectiveness test. It has impacts, effects and results [16]. Effectiveness refer to the extent that the experiences and outcomes with the intervention are consistent with the intended aims [17]. The effectiveness of mathematics learning devices at assessment stage can be viewed from the test results of students’ problem solving abilities after using the mathematics learning device based on PBL models. Validation of the final test was done by 2 mathematicians. During the validation stage of the problem solving test, there were several revisions that were conducted based on the suggestions of the validator. The validation results of the problem solving test questions obtained average around 86%. It means that problem solving tests was truly valid criteria.

PBL model based learning is stated effective if it is able to improve students’ problem solving abilities. This test was given to students of class X natural sciences. The number of students taking the final test was 22 students. The percentage of mastery learning outcomes can be viewed in Table 3.

Table 3. Percentage of Final Test

| Final Test | Completeness | Amount |
|------------|--------------|--------|
|            | Pass | Fail |        |
| Number of Students | 14   | 8     | 22    |
| Percentage | 63.64% | 36.36% | 100%  |

The table 3 applies that students who got Minimum Score are 14 of 22 students. This case shows that percentage of students above the Minimum Score was 63.64% and students under Minimum Score was 36.36%. the learning tools which has developed are categorized as effective if the students are in a good category. It means that they got above 50% or above standard minimum criteria. The students who were still able to achieve Minimum score was caused by their focus. They were not focus while doing discussion and not serious in doing the test. Therefore, it was caused that they were unable to answer the test correctly. It was contrary with the average initial test results of problem solving abilities. Their score of students at Class X natural sciences was 70.45; thus, based on the explanation above, it can be concluded that the students’ problem solving ability after using PBL model based learning device had increased. This shows that PBL model-based learning tools had been effective for improving students’ problem solving abilities.
4. Conclusion
Based on the results of research and discussion, it can be concluded as follows:
1. The development of PBL model learning tools consists of Lesson Plan, Worksheet and final test that had been validated by the experts:
2. The results of the study indicates that the PBL model-based learning device was able to fulfill the practical requirements the aspects of implementation, effectiveness and efficiency. It can be evidenced by empirical data. They were practicality questionnaire data of students and teachers and the results observations of learning implementation. Mathematical learning tools based on PBL models developed through a one-to-one evaluation process, small group evaluation and field tests. The final average practicality of the equipment obtained 84.8%. it was strongly practical category.
3. The results of the research proves that the learning mathematics based on the PBL model that was developed was effective. It is viewed from empirical data. In this case, it can improve students' problem solving skills. The score was 63.64% that achieved Minimum Score. The effective PBL model-based mathematics learning device was able to construct the students' knowledge. Therefore, it can improve students' problem solving abilities and create learner-centered learning (student center) that is suitable with curriculum 13.
4. This research can be recommended for the further researcher to conduct the other characteristic innovation of PBL based learning device. Furthermore, this research can be a reference in developing PBL based learning device. Especially in developing teaching material of lesson plan and worksheet at school.

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