Development of Problem-Based Mathematic Learning Model to Improve Creative Thinking Ability of Elementary Teacher Education Students, Bung Hatta University

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Abstract. A problem-based mathematic learning model with high validity, practicality, and effectiveness is produced to improve students’ competence. The stages on developing it consist of 1) preliminary stage, 2) proto-type stage including planning, evaluation, and revision, 3) product assessment stage. The mathematic learning model based on problem was tested to the college students of PGSD Department of FKIP, Bung Hatta University involving 30 students and 3 mathematic lecturers. The instrument used in this study consisted of 1) instrument of validity appraisal, component of learning model and toolkit, 2) instrument of practicality appraisal from students and lecturers, 3) effectiveness instrument covering test result and students’ appreciation appraisal toward problem-based mathematic learning model. The result showed that problem-based mathematic learning model including syntax/learning steps, along with learning tools in term of semester learning plan and students’ worksheet was considered valid, practical, and effective.

1. Introduction
The ability to think creatively is a potential every individual has, and the environment should encourage it to explore that potential. Each individual has a different way to explore his potential to make himself unique. This is what makes the ability to think creatively is a very influential aspect of the involvement of students to learn actively. This situation, of course, has a different impact on each student attending the learning process [1]. Actually, thinking creatively is always related to one's creativity in producing something new. In a learning process, the ability to analyse something creatively reflects students’ competence to explore the thought to seek a variety of answers or solutions [2]. With the creative thinking, the solutions to solve problems faced in learning mathematics can be found. So that, thinking creatively also can be another term of a mental activity in solving problems, expressing great ideas or views on available problems/ideas.

The ability of thinking creatively is a thinking process with various alternative answers based on the information given [3]. The most necessary traits of creative thinking abilities (divergent thinking) are: (1) Fluency, the ability in generating a lot of ideas. The smooth thinking reflects more the quantity than quality, (2) the ability to apply various of approaches and / or a way in solving the problem, (3) the ability of explaining a thing in detail, (4) the ability of creating great ideas or abilities as a result of one's own thoughts [4].
Students' creative thinking skills in learning can be developed as follows: (1) Teachers-students interaction should be a dialogue, not monologues, (2) questions given by teachers should encourage students to think creatively, (3) Questions given must enable students to use the thought process to conduct analysis, synthesis, and evaluation to answer, (4) respect unusual cases raised, (5) respect challenging ideas, (6) give students a chance to learn independently, (7) give awards to students, (8) take a moment for students to study and make themselves busy without judgment, (9) involve students to produce many good ideas in solving problems, (10) provide an atmosphere in which the students are stimulated to be creative, (11) too controlling should be minimized, (12) to be open-minded with students’ interests and ideas, (13) to give broad moment and chance to think and create ideas, (14) students are given many opportunities to participate in making decisions, (15) to create a warm condition and security for the growth of freedom of explorative thinking, (16) mutual respect and mutual acceptance between students and between teachers and students are provided, and (17) appreciate students’ effort and support them to raise [5].

Based on researcher’s experience in teaching Mathematics in PGSD majors (approximately 12 years), 90% of students were found to have low creative thinking skills. This had an impact on their low learning outcomes. Of the total PGSD students, only 10% of students liked mathematics (source: archive PGSD study program). 60% of students didn’t master the concepts gained in elementary or high school. 65% of students got panic when given complex math problems. Likewise, if given a question that was different from the sample questions given, 65% of students also could not complete it. The student low-cognitive thinking ability affected the low student achievement. The average of student learning outcomes in the last three years in mathematics courses was that only 60% of students got B and above, the rest were B-, C, D and E.

One learning model that can be developed to improve students' creative thinking is learning model based on problem (PBLM)[6]. This model exposes and explore most students with practical issues or in other words, students are explored with problems.

PBLM is an approaching using real world problems as a context for students to learn creative thinking and problem solving competence and to gain essential knowledge and concepts from the subject matter [1]. Problem-based learning is a learning strategy providing problems to be learnt by students [6]. Based on the opinions expressed previously, the problem-based learning model can be concluded as learning series in which the problems are the learning cases/questions/materials. The PBLM consists of 5 steps, namely: (1) Orienting students to the problem, (2) Leading students to experience learning, (3) Guiding students experiences, (4) work Development and presentation, (5) Analyzing and evaluating the process of problem solving. From the steps of Problem Based Learning, it is possible to develop students' creative thinking skills in formulating problems, processing information and analyzing problem solving processes. With the increase in students' creative thinking abilities, student learning outcomes will be able to improve [1].

Problem-based learning model is a structured learning model that enable students to build knowledge and problem-solving competence and help students master knowledge [7]. On its implementation, problem-based learning makes contextual problems as the beginning of the learning process. Giving problems at the beginning of the learning process is the main characteristics of problem-based learning, among others, namely: (1) gaining question or problem, (2) interdisciplinary focus, (3) authentic analysis, (4) producing artifacts and exhibits (5) working with team/group,(6) problem solving [8]. Problems presented in problem-based learning model are related to the learners’ daily life, meaningful and complex or avoiding simple answers. In problem-based learning model, the knowledge needed in the investigation process also includes a variety of knowledge in other fields that students have had before. Then, in conducting the investigation process to be able to find a solution, students need to identify and analyse problems, to develop hypotheses and make predictions, to collect and analyze information, to carry out experiments (if needed), and to draw conclusions [9]. Next, PBLM also requires students to produce an artifact for further presentation to other students. Another thing that may not be ignored in Problem-Based Learning is collaboration. The process of investigation and problem solving carried out by students is carried out with one friend or in a small group.

In addition, problem-based learning also has several advantages, one of which is that it can help students to improve achievement and high-level thinking skills [10]. This supports the research finding
conducted by other researchers [11]; problem-based learning model can improve learning achievement. This means that problem-based learning can be an option in mathematics learning that has a great opportunity to achieve the goals of mathematics learning.

In accordance with the explanation above, it is always necessary to develop improvement in mathematics learning. Thus in this study, a problem-based learning model was developed in order to produce a model that meets valid, practical, and effective criteria that can be applied in mathematics learning.

2. Research Methods
This study aims to develop and produce a mathematical learning model with a problem-based learning model. To develop the model required in-depth study on the components involved in the lesson among which are semester-learning plan and Students work sheet. This research also involved other parties in developing the intended learning models such as lecturers and students. Therefore this research was designed using a research and development approach or research and development (RnD). The RnD method has the idea of combining three mutually supportive methods to produce a model, namely a preliminary study, evaluative process at the stage of the model and experimental testing process at the stage of the efficacy test model [12].

Research and development is the research methods used to produce specific products and examine the effectiveness of such product [13]. Research and development research is one whose purpose is to develop and validate the products used in education [14]. The development model used in this study refers to the development stage proposed by Nieven which includes (1) the preliminary stage, (2) prototyping stage), (3) assessment stage [15]. Furthermore, the quality of problem-based mathematics learning models also refers to Nieven's quality criteria including valid, practical, and effective criteria.

In developing the problem-based learning model, the steps of the preliminary activity in the form of curriculum analysis used in the Primary School Teacher Education Study Program in the Mathematics Learning II course were carried out. Furthermore, the measurement of product validity was carried out through Expert Judgments / Expert Tests and Focus Group Discussion. Meanwhile, the practicality of product application test was carried out to students in the form of a product practicality questionnaire. This research was targeted to produce problems-based learning tools that are valid, practical and effective and can improve students creative thinking abilities, such as syllabus, Semester Implementation plan and students work.

The procedure for developing a mathematics learning model with a problem-based learning model approach was carried out with the following details: (1) Needs Analysis; This analysis includes analysis of learning facilities and infrastructure, student needs, student characteristics, analyzing educator's abilities in solving the obstacles encountered during mathematics learning, (2) Design; At this stage, the first thing to do was to establish the main concepts of mathematics learning with a problem-based learning model approach that was integrated into learning material of the mathematics course at the Elementary School Teacher Education Study Program of The Faculty of Teacher Training and Education Bung Hatta University. The next steps were conducting theoretical and literature reviews on mathematics learning with a problem-based learning model approach in supporting learning equipment and mathematics learning textbooks, (3) conducting try out, product evaluation and revision; After the product was produced either in the form of learning devices or mathematics learning textbooks, product validity tests were conducted focusing group discussion and expert testing/expert judgment in stages starting from small, medium and large groups. Each stage has an evaluation and revision and inputs and suggestions from the results of the focus group discussion and expert testing / Expert Judgment. Then from the results of small-scale trials, the effectiveness and response of students were seen through questionnaires that was filled by students and lecturers. The results of this questionnaire were also a basis for continuous evaluation and revision of products.
This research was conducted in 2017-2019 at the Elementary School Teacher Education Study Program of The Faculty of Teacher Training and Education Bung Hatta University Padang. In developing this problem-based mathematical model, three experts were involved, namely lecturers from the Elementary School Teacher Education Study Program to determine the validity of the learning model. Furthermore, at the trial stage, the problem-based mathematics learning model involved 26 students taking the Mathematics Learning II course. And at the application stage, the classroom action research was carried out in 2 cycles.

The data in this study consisted of quantitative and qualitative data. Quantitative data were obtained from the results of the validity assessment sheet by experts, practicality assessment sheets from lecturers and students, the test results of students’ mathematics learning, questionnaire results of students’ creative thinking abilities and observations. Meanwhile, the qualitative data werein the form of input and suggestions from experts (lecturers) or students as material for improving the learning model, observational data during the implementation of class actions.

The instruments used in this study consist of (1) validity instruments which include (a) assessment sheet on the validity of learning model components, and (b) assessment sheet on learning support device (Semester Learning Plan, Student work sheet, learning outcomes test);(2) practicality assessment instruments which include (a) assessment sheets from lecturers, and (b) assessment questionnaires from students; and (3) effectiveness assessment instruments which include (a) learning outcome test sheets, and (b) student appreciation questionnaires on problem-based mathematics learning; (3) instruments to improve students’ creative thinking abilities include (a) sheets of validity of learning implementation by lecturers, (b) questionnaires on students’ creative thinking abilities, (c) learning outcomes test sheets.

The validity of problem-based mathematics learning models is determined by expert judgment. Scores obtained from the assessment sheet on validity, practicality and effectiveness of the learning model are converted into qualitative categorization refering to the following categorizations.

| Table 1: Categorization of Score Scores | Score Average Interval | Value | Category |
|---------------------------------------|------------------------|-------|----------|
| 4.00 \( \leq X < 3.00 \)             | A                      | Very good |
| 3.00 \( \leq X < 2.00 \)             | B                      | Well |
| 2.00 \( \leq X < 1.00 \)             | C                      | Not good |
| 1.00 \( \leq X < 0.00 \)             | D                      | Not good |

The learning model is said to be valid if a minimum of expert judgment on the components of the learning model and learning support devices reaches good criteria. Furthermore, the problem-based mathematics learning model is said to be practical, if the results of the lecturer and student assessment reach at least good criteria (B) . The effectiveness of learning is determined by learning outcomes and the level of student appreciation for problem-based mathematics learning. Problem-based mathematics learning model is effective if the results of classical learning completeness are at least 75% with a minimum value of B. In addition, problem-based mathematics learning models are said to be effective if the level of student appreciation for problem-based mathematics learning reaches at least effective criteria. The improvement of students’ creative thinking skills was obtained through questionnaire data filled in by students. The results of the questionnaire data were gained through scoring each indicator according to the questionnaire scoring guidelines for creative thinking skills. Then each indicator studied from the ability to think creatively from the score of all students who filled in the questionnaire was summed and determined the percentage of score. Results of score percentage is categorized as follows:

| Table 2: Criteria for Creative Thinking Ability Based on Questionnaire Score Percentages | No. | Percentage of Scores | Criteria |
|------------------------------------------|-----|----------------------|----------|
| 1                                        | 89% \( < x \leq 100\% \) | Very high |
| 2                                        | 79% \( < x \leq 89\% \) | High |
| 3                                        | 64% \( < x \leq 79\% \) | Is being |
| 4                                        | 54% \( < x \leq 64\% \) | Low |
| 5                                        | \( x \leq 54\% \) | Very low |
3. Results And Discussion

The learning model developed in this study was problem-based mathematics learning consisting of syntax / learning steps, social systems, reaction principles, and instructional impacts. The more detail stages of the research are described as follows:

3.1. Preliminary Research Phase

Information collection is done by analyzing mathematics learning subject matter according to the curriculum that applies in Program. The analysis was carried out together with 3 lecturers who taught Mathematics Learning 2 subjects in Elementary School Teacher Education Study Program. From the teaching experience so far the lecturer complained that it was very difficult to grow the way students think. When given questions, they cannot solve the problem well. If given an example of completion, they understand, but when given different questions they cannot complete it. Likewise the understanding of the prerequisite material possessed by Elementary School Teacher Education Study Program students is very minimal. Many basic concepts that they must have from prerequisite courses are not mastered by them. So that a learning approach is needed that can arouse student creativity. Learning tools need to be made that can make it easier for students to understand the material provided. Media needs to be made that can improve student skills. Learning tools needed for the learning process to run systematically to achieve the desired goals, are Semester Learning Plans and Student Work Sheets.

3.2. Development Phase (Prototype Design Results)

The following will describe the characteristics of Semester Learning Plans and Student Work Sheets of problem-based mathematic learning that have been designed. Semester Learning Plans is designed as guidance for lecturers to carry out learning. The Semester Learning Plan component is designed in accordance with the guidelines for higher education curriculum compilation and regulation of Bung Hatta University rector, Number 1 of 2015 concerning the Implementation of Education

3.3. Results of Learning Device Validation

Based on the results of expert assessment of the validity of problem-based mathematics learning models, it can be shown that the components of problem-based mathematics learning reach very valid criteria. The results of expert assessment of the components of problem-based mathematics learning models can be seen in Table 4 below.

| No. | Component                     | Average Score | Criteria    |
|-----|-------------------------------|---------------|-------------|
| 1   | Syntax                        | 3.7           | Very valid  |
| 2   | Social System                 | 3.6           | Very valid  |
| 3   | Principle of Reaction         | 3.6           | Very valid  |
| 4   | Companion and instructional impact | 3.5    | Very valid  |

Scores and Criteria for the Results of Validity Evaluation of Problem Based Mathematics Learning Model are very valid criteria for all aspects assessed. Both of Syntax, Social System, Reaction Principles and companionship and instructional effects are all very valid. Thus the resulting learning model is feasible to use.

Furthermore, the results of the validity of the learning support device in summary can be seen in Table 5 below.
Table 5. Scores and Criteria for Results of the Validity Assessment of Problem-Based Mathematics Learning Tools.

| Product                    | Average Score | Criteria  |
|----------------------------|---------------|-----------|
| Semester Learning Plans    | 3.5           | Very Valid|
| Students Work Sheet        | 3.6           | Very Valid|
| Learning Outcomes Test     | 3.7           | Very Valid|

Based on table 5, the three learning devices meet very valid criteria. Furthermore, the results of the practicality assessment of students also showed that the problem-based mathematics learning model very valid practical criteria (3.8).

3.4. Test Results of Learning Devices

Based on the results of testing the problem-based mathematical learning model for PGSD students has gone very well. At the initial stage, students experience obstacles. Moreover, the problems given have divergent answers. So that students’ answers are very diverse. Moreover, the answer column provided is no demand for problem solving. Thus, it will be able to increase student creativity. The impact of the learning process that has been running well can be seen from the good student learning outcomes. From the student learning outcomes data obtained 90% of students obtain a B value. This shows that mathematics learning using problem-based learning is effective. From the level of appreciation, a student of the mathematical models of problem-based learning, which is very good also high (3.8).

In the process of problem solving, students managed to determine the appropriate problem-solving strategy, then the next thing to do is to implement the student the strategy. During the learning process, students are given the freedom to be able to determine and implement existing problem solving strategies. Lecturers in this matter act as facilitators and at the same time as evaluators to help ensure students that the steps taken by students are appropriate. As long as the problem solving process takes place, lecturers always remind students to ensure that the answers or solutions obtained by students are correct by asking students to re-examine the calculations and steps taken by students. However, during the trial process, there were still students who missed the stage of reviewing the answer / problem solving.

Furthermore, data from student appreciation questionnaires on problem-based mathematics learning also showed that students’ appreciation of learning had reached effective criteria. Thus, it can be said that the problem-based mathematics learning model meets the effective criteria.

3.5. Results of Class Action Implementation

3.5.1. Cycle 1 Research Results

Based on the observation sheet, the lecturers' activities were filled in by the observers in the implementation of learning. In this first cycle, researchers got an average of 57.59% with a fairly good category. This means that there is a need to improve the implementation of learning carried out by lecturers. It must be examined again the learning steps that have been planned. The data obtained from the assessment of students’ creative thinking skills were obtained through questionnaires on students’ creative thinking abilities. In this first cycle the overall percentage of students’ creative thinking abilities obtained was 72.55%. With this percentage already classified into the criteria of being. This has not yet reached the expected criteria, namely the good category. Next reflection is done to see whether the implementation of learning is in accordance with the planning and to see whether the halal indicator has been achieved or not, and to see corrective actions that need to be carried out in the next cycle. Based on the results of the analysis of observation data, the results of questionnaires and student learning outcomes it turns out that the indicators of success have not been achieved, it was decided to continue the research to cycle 2. Improvements to be carried out in cycle 2 are as follows; (1) For apperception activities should be packed with problems or events that are more challenging for students to think
creatively. Lecturers must monitor students' participation in discussions, because there are still students who are not involved in discussion activities; (2) Lecturers are more conditioned students to respect their friends who are presenting the results of the group report in front of the class; (3) The time used is sought in line with the planned time allocation.

3.5.2. Cycle II Research Result

Planning cycle II is arranged in accordance with the reflections carried out in the first cycle, starting from guiding and paying attention to students when learning takes place to organize time well. Actions taken in accordance with the existing measures on Student Work Sheets. Observations were made to determine the students' critical thinking skills and lecturer activities in the classroom. Furthermore, from the results of the reflections carried out, it is continued in cycle 2. In cycle 2 students are still given the opportunity and facilitated to demonstrate creative thinking skills in learning activities take place, both individually and in groups through the problems given on worksheets that must be done in groups and then discussed. While lecturers still play a role as motivators and facilitators. Each meeting was observed by the observer. After completing the learning session as many as 4 meetings, the questionaire was given an effective thinking ability. Furthermore, the data from observations and questionnaire results were analyzed. The results of the analysis are described as follows.

The success of students in learning is generally seen also from classroom management conducted by lecturers through the Problem Based Learning model. Lecturer activities in cycle two II are classified as good with a percentage of 78.40%. The percentage of lecturers in managing learning has increased from the previous cycle. In this second cycle, the percentage of students' cognitive thinking skills has increased. The indicators draw conclusions and action there is a fairly high increase compared to the other indicators. In this second cycle the percentage of students' creative thinking abilities increased to 76.77%. The percentage increase in the 4th indicator is higher compared to the first cycle because students are getting used to the questions given.

The results of the analysis of the whole aspects in cycle 2 indicate that indicators have been achieved that demonstrate the effectiveness of the implementation of problem-based learning. Based on the results obtained in general the overall learning activities in the implementation of the actions can be implemented effectively. During the discussion (group discussion and the class discussion), it was found that the students were active and involved totally, which includes activities to identify and understand the problem, ask and answer the problems, solve the problem, make decisions, and interpret and deduce problems which was on the group worksheet. When learning is in progress the class atmosphere is conducive, because each student is quite focused and enthusiastic about doing their respective assignments. All students are involved in finding concepts and solving problems given correctly. The questions asked are already high-level questions. This illustrates that the students have been negative in solving problems. Thus the indicator of the success of the research has been reached, the cycle is stopped.

Based on all the studies above, it can be stated that the development of problem-based mathematics learning is a learning that has been tested for validity, practicality and effectiveness, and improved students' creative thinking skills so that they can be considered for use in mathematics learning Elementary School Teacher Education Study Program.

4. Conclusion

After the stages of development that have been carried out, a problem-based learning model has been produced. Problem Based Mathematics Learning Model that meets valid, practical, and effective criteria consists of components; (1) problem-based mathematics learning syntax consisting of steps, namely (a) student orientation on a problem, (b) organizing student to study, (c) solving mathematical problems that include the stage of understanding the problem, planning the strategy, implementing the strategy, and reviewing the solution obtained, (d) presenting the work, and (e) analysis and evaluation; (2) social systems in problem-based mathematics learning, namely lecturers acting as facilitators and evaluators of mathematical problem solving processes, learning centered on the mathematical problem solving process by students and is democratic for students to express opinions; (3) the principle of reaction in
problem-based mathematics learning, namely lecturers guiding and emphasizing the mathematical problem solving process by students, as well as lecturers evaluating and providing feedback on the results of students' mathematical problem solving; (4) supporting systems of problem-based mathematics learning, namely contextual problems and relating to the daily lives of students included in the students worksheet, the availability of learning resources and teaching aids; (5) the instructional impact of problem-based mathematics learning, namely the achievement of competencies and mathematical problem solving processes, while the secondary impact is the skills to work together and increase the ability to think creatively.

The validity of problem-based mathematics learning models is based on expert judgment, namely (1) syntax, social system, reaction principle, and instructional and secondary impacts have reached very valid criteria; (2) learning devices in the form of semester learning plans, Student worksheets and learning outcomes tests also have reached very valid criteria. The practicality of problem-based mathematics learning models was based on (1) the assessment of lecturers has reached very practical criteria; (2) the assessment of students has achieved very practical criteria. The effectiveness of problem-based mathematics learning models was based on (1) result of student learning outcomes tests has met the requirements of effectiveness whose percentage of students who achieve a minimum B score was 90%, (b) student appreciation for problem-based mathematics learning reaches good criteria. The application of the Problem Based Learning model is effective in improving students' creative thinking abilities.

Thus, it can be concluded that the result of learning model is valid, practical and effective in improving students' creative thinking abilities.

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