The development of learning instruments through the problem-based learning model to enhance students’ creativity

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Abstract. Lack of opportunities for students to express ideas during the learning process makes students having difficulty in solving their daily life problems. Realizing the importance of mathematical creative thinking ability, it required the development of learning tool through Problem Based Learning (PBL) model. This study aimed to develop the valid learning tools through the PBL model to improve the creativity of students. Learning tools were developed based on the 4D model, that refers to define, design, develop, and disseminate. However, this research only focussed on the first three stages. The results showed that learning tools through the PBL model in improving student creativity meet the criteria of validity, in which the score was 4.13 (highly valid). Furthermore, the learning tools developed through the PBL model in this study can be used for further analysis, including in practicality and effectiveness phases.

1. Introduction
Developing students’ creative thinking skill is crucial in mathematics learning. When someone applies creative thinking in solving the problem, diverging thinking will produce many useful ideas to solve the problem [2]. In addition, creative thinking contributes to finding ideas in problem-solving to produce individual solutions for students themselves [3,4]. In the Indonesian context, the national curriculum of 2013 aims to make students think creatively [1]. The curriculum requires students to think widely and convergently to develop innovations in all areas of mathematics. Therefore, mathematics teachers need to develop the learning instruments that could foster students’ creative thinking skill.

Based on the preliminary research of this study, the test of students’ mathematical creative thinking ability at one of the high schools in Banda Aceh showed that only 22 students (73.33%) were in middle level, 8 students (26,67%) were in the low level, and no one was at high level. This data showed that students' creative thinking skill did not show maximum results. Thus, it is necessary to develop learning instruments that can train students' mathematical creative thinking skills by embedding meaningful learning model, such as Problem Based Learning (PBL) model. Learning instruments that were developed in this study included lesson plans, student worksheets, and test. The lesson plans were developed based
on the steps in the PBL model, while the student worksheets and test were developed based on appropriate indicators of mathematics creative thinking skill.

In the PBL learning process, students need to deal with real-life problems, wherein students could develop their knowledge that contributes to their learning experiences [5]. In addition, in the learning model, students were trained to model the problems into mathematical concepts. Each student could think about various solutions which could raise the level of students creativity.

The general step in the PBL model is to propose the problem. Problem-based teaching is not only to lead to certain academic principles or skills but also to direct the learning issues that would be meaningful to students [6]. The given problems were based on authentic real-life situations that allowed various solutions to one problem. Next, the students conducted authentic inquiries to find solutions to a given problem. Students were required to express various ideas and interpret the problems, develop hypotheses, collect and experiment when needed. These activities could accommodate the creative thinking aspects of fluency and flexibility. In addition, students could add original ideas to solve the problems. The final stages of problem-based learning were planning and preparing reports in the form of works that explain the solution they had found. This activity could develop ideas to enrich existing ideas, thereby developing elaboration aspects.

Based on the description of the introduction, it is generally formulated the principal issue of research as follows: How to develop learning tools through PBL model in improving the creativity of students who meet the valid criteria?

2. Methods

This study was a development research. I was used the 4D model consisting of 4 stages of development, namely define, design, develop and disseminate [7]. This study only carried out until the third stage. The define stage involved literature review to determine the characteristics of learning instruments that could improve students’ creative thinking ability. Also, this stage included an initial curriculum analysis with the help of mathematics teachers to identify the mathematics topics that needed development of learning instruments. The design stage aims to design an instrument that can be used in learning mathematics. The design stage involved four steps, including the preparation of tests, the selection of media that was suitable to the characteristics of learning materials, the format selection and make the initial design according to the selected format.

The development stage involved the expert validation that followed by twice revisions. The initial learning instruments were validated by three validators, including two lecturers as the experts of teaching and learning mathematics and a high school mathematics teacher as a practitioner of mathematics learning. The validation process was conducted by using a questionnaire for each instrument, whose scale from 1 to 5 (invalid to highly valid). The criteria used for assessing the learning instruments were based on Plomp and Nieveen [8] as shown in Table 1.

| Score | VS | Criteria |
|-------|----|----------|
| 4 ≤   | ≤ 5| Highly valid |
| 3 ≤   | ≤ 4| Valid     |
| 2 ≤   | ≤ 3| Less valid|
| 1 ≤   | ≤ 2| Not valid |
3. Result and Discussion

3.1 Define stage
At this stage, the researcher discussed the challenges faced by teachers when they taught the absolute value concept. The discussion aimed to obtain the information about students’ condition when learning mathematics. Teachers admitted that the topics of absolute values had been one of the challenging topics to develop the proper learning tools that could improve students’ creative skills. One of the challenges mostly found by students was the topics of linear equality and linear inequality. Whereas, students’ comprehension on these topics was pre-requisite before students learning the topics of absolute value [9]. Students who have the poor understanding of the basic concepts would have difficulties in learning new topics, which might result in a low quality of students’ creative thinking skill. Therefore, the learning tools that were developed in this study consisted of the concept of absolute values, including illustrating the graph of the problem of absolute value and solving problems related to absolute value in equations and linear inequalities.

3.2 Design stage
At this stage, the learning instruments, including lesson plans, student worksheets, and test questions, were developed based on the results of the analysis at the define stage. The results of the learning instruments at the design stage were called draft 1. The lesson plan was designed by using problem-based learning model, that was indicated by including student-centered problem, encouraging students to learn, guiding individual and group investigations, developing and presenting the work, and analyzing and evaluating the problem-solving process. The lesson lasted for four meetings, $2 \times 45$ minutes for each lesson. In general, the developed lesson plan had the similar aspects to the typical lesson plans. Only the motivation part had differences, which aimed to help students to understand the concept of absolute value by posing the daily life problems. The following question was one of the examples that was posed in the motivation section of the lesson plan.

Andi plans to travel home from Banda Aceh to Lhokseumawe through Sigli. The distance between Banda Aceh and Sigli is 110 km, while the distance from Sigli to Lhokseumawe is 166 km. Thus, the distance between Banda Aceh to Lhokseumawe is 276 km. The route of these cities could be seen in Figure 1.

![Figure 1. The route of the three cities](image)

If Sigli city is supposed to be a 0 point on the number line, Banda Aceh city is on the positive side of the number line, and Lhokseumawe city is on the negative direction of the number line. Then:

- What is the distance from Lhokseumawe to Sigli?
- Do you think the distance between Banda Aceh and Lhokseumawe is equal to the distance between Lhokseumawe to Banda Aceh? If so, could you explain why?
- If we write the distances on the number line, is it possible the distances to be negative?

In addition to motivation section on the lesson plan, the researcher also revised the at the “observing phase” on the scientific learning approach in student worksheets. The worksheets question was written in word problems, to help students to improve their ability to model mathematics question to the mathematical equation. Moreover, student worksheets were designed to encourage students to learn
actively and to develop students' creative thinking skills. The student worksheets were designed to measure students' creative thinking ability on equality and inequality of absolute values. Figure 2 shows one of the parts of the developed worksheets that included the “observing phase”.

![Figure 2. The sample of the developed student worksheets](image)

The design of the test questions also involved a rubric that matched the indicator on the ability of mathematical creative thinking in the topics of absolute value. Figure 3 shows the sample of the developed test questions.

![Figure 3. The sample of the developed test](image)

Problem

Smoking is a social disease of teenagers nowadays. Medical experts stated that smoking one cigarette could reduce life expectancy by 5.5 minutes. A teenager has started smoking one cigarette daily since he was 15 years old, how long the life expectancy of the teenager that might be reduced if he is 40 years old now? (Hint: 1 year = 365 days)

Solution:

What is known: ...........
What is asked: ...........
How long he’s been smoking:......
How many cigarettes that have been smoked:......
Hence, the life expectancy that has been reduced:....

The students who have the development of creativity have the awareness to arouse curiosity and the desire to always practice in solving math problems. This is inseparable from the scope and context of learning which is an important point in the contribution of developing creativity in the cognitive domain of students [11]. Several factors can improve the creativity of students, including 1) a suitable environment, so that students feel comfortable and not afraid to express ideas, 2) teacher personality traits that motivate students to develop ideas, 3) substantial study groups so that students exchange mind in solving problems [12]

3.3 Develop stage

At the develop stage, the learning instruments developed at the design stage were then validated by validators. The results of evaluation of the learning instruments by the validators are shown in Table 2.
Table 2. The result of the validator's assessment of the learning device in draft 1

| Validated instrument       | Average | Criteria       |
|---------------------------|---------|----------------|
| Lesson plan               | 4.2     | Highly valid   |
| Student Worksheets        | 3.4     | Valid          |
| Test                      | 4.8     | Highly valid   |
| **Average**               | 4.13    | **Highly valid** |

Based on the validator's assessment of the learning instruments, generally, the average validation level for the developed learning instruments was at the value of 4.13, suggested that averagely the instruments was very valid [9]. Both the lesson plan and the test of mathematical creative thinking ability met the highly valid criteria, whose the average scores of 4.2 and 4.8 respectively. Meanwhile, the student worksheets had an average score of 3.5, which indicated that the instrument was at valid level. Nevertheless, these scores have not yet fulfilled the maximum targeted score, which was 5, since the instruments was revised twice only as suggested by the validators. The validity level might have been higher if it involved more revision and validation processes. Also, the number of the validators involved in this study were only three people. Whereas, the more number of validators involved might have resulted in the higher level of validity scores, as it would have provided more constructive advice from different perspectives for the improvement of the instruments.

Furthermore, a summary of revisions before and after revisions of learning tools is shown in the following table.

Table 3. The results of validation of research instruments

| No | Before validation | After validation |
|----|-------------------|------------------|
| 1  | Lesson plans      |                  |
|    | • The perception used was not compatible with the topics | • The perception used has been relevant to the material |
|    | • The sentence used was not logical | • Sentences are logical |
|    | • The student worksheets were not included in the lesson plan | • The student worksheets were included in the lesson plan |
| 2  | Student worksheets |                  |
|    | • The instructions for working on student worksheets were too long | • The instructions used have been adjusted |
|    | • There was no image to draw the attention of learners in working on student worksheets | • There are already some pictures that match the question |
|    | • To provide the students with the steps of solving the questions on the student worksheets | • Only provided students with the empty space to solve the question by themselves to increase students’ creative thinking skill |
| 3  | Test              |                  |
|    | • The third question needed to be transformed into a matter of everyday life | • The third question was adapted to the problems of everyday life |
4. Conclusion

It can be concluded that the learning instruments through the PBL model in improving students’ creative thinking skill met the criteria of validity. While the lesson plan and test questions had highly valid scores (4.2 and 4.8 respectively), the student worksheets were at a valid level (3.4). Nevertheless, on average, the developed instruments were highly valid, with an average score of 4.13. Moreover, the developed learning instruments of the PBL model to improve students’ creative thinking skill can be tested for future teaching and learning practices, as well as to the further research.

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