Development of learning tools using Treffinger learning model to improve creative thinking

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Abstract. The mathematical creative thinking is essential for students. The initial test indicated that students’ creative thinking ability is still lacking. Treffinger learning model deals with creativity problems. Based on the needs analysis, Treffinger learning instruments was not available. This study aimed at developing and producing valid and practical learning instruments using Treffinger learning model to improve the junior high school students’ mathematical creative thinking. It was a developmental research that refers to the ADDIE development model. The results of this study indicated that the learning instruments satisfy the validity requirements and the results of the validity test by validators showed that instruments were valid and based on the agreement among validators results classified as the good category. Its practicality can be seen from the results of the learning implementation (93%). In addition, the results of teacher responses were classified as ‘very good.

1. Introduction
The mathematical creative thinking ability is one of the mathematical skills that must be acquired by students in learning mathematics. In fact, the development of creative thinking ability is one of the focuses of mathematics learning [1]. Thus, the learning applied by teachers should be oriented toward creativity, encouraging students to discover their own solutions from the different point of views [2]. Our societies require creative thinking more and more than in the past [3]. Creativity draws new relationships between experience and knowledge, it also proposes new solutions to problems [4]. Students can develop their creative thinking ability that they can qualify the development of globalization era and compete with others in the future [5].

It is found that students are lacking mathematical creative thinking. This is indicated by the test results of mathematical creative ability administered to 82 junior high school students in Banda Aceh. The test showed that an average of 67.68% of students did not solve the mathematics problems using more than one solution, though the problems provided in the test requires students to solve it in at least two different ways. While, 10.37% of learners have solved the problem in the test providing at least two different ways, yet one of the solutions presented was wrong. Only 20.73% of students answered the questions using at least two ways and they were correctly done. Less than two percent of the students (1.22%) did not answer the problem or all the answers provided were incorrect. Figure 1 presents a problem used to examine the students’ mathematical creative thinking ability adapted from Siswono [6].
A fish has three parts of the features, namely head, body, and tail. Each part weight in kilograms.

a. How many kilograms may the weight of the fish be? Write down how to solve it. Are there any other possible answers? If there are, mention at least two possible answers.

b. Check the answers you have obtained. Show two or more different ways to get the answer.

One of the students’ answers is presented in Figure 2.

![Figure 1. A problem used to examine the students’ mathematical creative thinking ability](image)

**Figure 2. The result of students’ initial test**

The student’s test result in Figure 2 shows that the students had given the correct answer for the given problem, however, it was only solved using one strategy despite the questions asking the students to solve the problem using at least two different ways. In this case, the researchers also conducted interviews with the students and it is noted that the students were not aware of other ways to solve the problem.

Treffinger learning model is one of the learning models specially designed with the learning stages to trigger students’ creative thinking ability involving both cognitive and affective skills. The Treffinger model encouraging creative learning consists of three stages arrangement started from the basic elements and rise to the more complex functions of thinking; students are engaged in skills building activities in the first two stages and later deal with real-life problems on the third phase [7]. In addition, the Treffinger model consists of the following steps: level 1 provides the foundation upon which creative learning develops by including a variety of important techniques basic to creative learning. In level 2, the basic cognitive and affective factors from level 1 are extended, higher-level or more complex thinking skills are employed, along with transformation of products and processes, analogies and metaphor, methodological or inquiry skills, dealing with complex feelings and tensions, imagery, and the development of psychological freedom and safety. Level 3, the final level, involves the person in real problems and challenges [8].

One attempt that should be considered to support the learning process triggering the students’ mathematical creative thinking ability is the design of learning instruments. All of the teachers in the educational unit is obliged to develop a complete and systematic learning instruments to ensure that the learning is interactive, inspirational, fun, challenging, and motivating the students to be actively engaged, creative, and independence based on their talents, interests, as well as their physical and psychological development [9]. In fact, it is hard to imagine teachers becoming more effective over time without being able to analyze teaching in terms of its effects on student learning [10]. This is confirmed by [11] who stated that teachers need to analyze the concepts of the material and carefully plan the learning before conducting the learning in the classroom.

Based on the needs analysis conducted by the researchers in three junior high schools in Banda Aceh, neither the learning instruments using the Treffinger learning model nor the learning model demanding students in thinking creatively was available. Therefore, there was a need of developing of learning instruments using creative learning model, one of which is Treffinger. The purposes of this
study were to describe the development process and produce a valid and practical mathematics learning instruments by using the Treffinger learning model to improve junior high school students’ mathematical creative thinking ability.

2. Method
This is a design research. The subjects in this study were 30 Year 7 students of one of the Islamic junior high schools in Meulaboh. The quality criteria of the learning instruments refer to the criteria set by [12], while the design of learning instruments refers to the development model of ADDIE. The data in this study was obtained by observing the implementation of learning activities and examining the teacher's response toward the implementation of learning using the learning instruments of Treffinger learning model. Data analysis of the validity test was carried out by calculating the average score the developed learning instruments assigned by the validator. The validity criteria used is adapted from [13] and are presented in Table 1.

| Average | Validity criteria |
|---------|------------------|
| 4 ≤ TV ≤ 5 | Highly valid |
| 3 ≤ TV < 4 | Valid |
| 2 ≤ TV < 3 | Quite valid |
| 1 ≤ TV < 2 | Invalid |

The practicality test of the learning instruments was conducted in two ways, namely: observing the implementation of learning instruments and examining the mathematics teacher responses to learning instruments designed. The implementation of learning was carried out by converting the percentage of learning activities (k) into a qualitative value adapted from the qualification of learning implementation used by [14] as shown in Table 2.

| Percentage | Criteria |
|------------|----------|
| 80% ≤ k< 100% | Excellent |
| 60% ≤ k< 80% | Good |
| 40% ≤ k< 60% | Adequate |
| 20% ≤ k< 40% | Less |
| 0% ≤ k< 20% | Much less |

Average score of the practicality test (p) based on the teacher’s response to the questionnaire and it was then converted to qualitative criteria [15], as presented in Table 3.

Besides using the average formula, the data analysis of validity and practicality test was also reinforced by inter-rater test. This was conducted to examine the perception or agreement between the validators and the teachers/practitioners toward the Treffinger learning instruments employing the assessment criteria of kappa proposed by [16] as follows KK < 0.4 (categorized as bad), 0.4 ≤ KK ≤ 0.75 (categorized as good), and KK > 0.75 (categorized as excellent). The inter-rater test in this study was obtained by generating kappa coefficients using SPSS 23.0. The learning instruments are said to
be valid and practical if kappa is greater than or equal to 0.4, otherwise the learning instruments needs to be revised.

### Table 3. The classification guidelines of teacher practicality

| Interval Score | Criteria |
|----------------|----------|
| x > 4.2        | Excellent|
| 3.4 < x ≤ 4.2 | Good     |
| 2.6 < x ≤ 3.4 | Adequate |
| 1.8 < x ≤ 2.6 | Less     |
| x ≤ 1.8       | Much less |

3. Results and Discussion

The process and the results of designing mathematics learning instruments using Treffinger learning model to improve mathematical creative thinking ability is described in the following sections.

#### 3.1 Analyzing stage (analysis)

The activities undertaken at this stage were performing the needs analysis consisting of the analysis of students’ mathematical creative thinking ability conducted by administering a creative thinking ability test, the analysis of the availability of learning instruments, and the curriculum analysis.

The result of the needs analysis showed that the mathematical creative thinking ability in three schools was lacking. This was indicated by the test results reported that 71% of the students participated in the test was less fluent in expressing ideas to solve the problem, 24% of the students was rather fluent and only 5% of the students fluently expressed the ideas to solve problems on the creative thinking ability test. For the indicator of flexibility, 76% of the students only provided one way/solution to the given problem even though the instructions required students to answer the problem with more than one way/solution, and only 4% of the students were managed to solve the problem by presenting more than one way/solution. For the indicator of authenticity (originality), it was noted that no student provided different or unique answers compared to other students. Furthermore, there was no lesson using the Treffinger learning model or the learning stages requiring students to think creatively. The activities in the students’ worksheet were also found to highly guiding students in solving problems, consequently, students were not given the freedom to explore their ability in various ways/solutions. In addition, the test conducted to evaluate the students’ learning outcomes did not allow the students to solve the problem in various ways/solutions or provide the instruction requiring students to present various ways/solutions in solving the problem. Therefore, the development of the learning instruments aiming to improve students’ creative thinking ability is required.

#### 3.2 Designing stage (Design)

Once all steps of the needs analysis have been conducted, the initial design of learning instruments was created. The first step carried out at this stage was studying the problem and finding alternative solutions to solve the problems found in the needs analysis. The results obtained at this stage was that the researcher developing the mathematics learning instruments using Treffinger learning model to enhance junior high school students mathematical creative thinking ability. The topic chosen for these learning instruments was rectangular plane geometry, consisting of parallelogram, trapezium, rhombus, and kite taught in the second semester of Year 7. This topic was suitable to be taught by using the Treffinger learning model as well as improving the mathematical creative thinking ability as it can be solved in various ways/solutions.
3.3 Developing stage (Development)

The subsequent stage was to develop the learning instruments that starting with determining the test items needed to measure the ability in accordance with the purpose of learning. This resulted in problems for student worksheet that was tailored to satisfy the indicator of the ability to think creatively using the syntax of Treffinger learning model as activities should be completed by the students. The next step was developing a lesson plan which format was adapted from the ministry regulation number 22 of 2016. The researchers later developed the teaching materials consisting of two parts of the rectangular topic that is the introduction of the rectangular plane geometry as well as the area and perimeter of the rectangular geometry plane. Finally, a test of learning outcomes aiming to evaluate the learning activities was also developed. The products obtained in this step were learning instruments consisting of lesson plans, student worksheets, learning outcome tests and teaching materials.

The learning instruments were validated by the validators. Content and construct validity expressed by the experts and practitioners were used to indicate whether the instruments were valid. The validity aspect of a learning instruments can be identified from (1) content validity, i.e. the instruments was strongly developed based on the theoretical rationale, and (2) construct validity, i.e. there is internal consistency between each component in the instruments [12]. The validation of the learning instruments in this research was carried out twice as the first validation phase of student worksheet and test of learning outcomes were classified as the bad category, and therefore, they should be revised and revalidated. While, the lesson plan and teaching materials were declared as valid in the first validation phase and classified as good category based on the validators’ perception. Nevertheless, both teaching materials and lesson plan were also revised in accordance with the suggestions provided by the validators. The revisions made based on the validators’ suggestion included the multiple interpretations language or sentence, the stages of learning, and the inappropriate problems and learning activities to improve the mathematical creative thinking ability using Treffinger learning model. The second validation stage indicated that the learning instruments met the valid criteria based on the validator assessment results and the agreement between the validators. The Kappa values ranged from 0.588 to 1.000 for lesson plan, 0.545 to 1.000 for student worksheet, 0.409 to 0.755 for test of learning outcomes, and 0.462 to 0.611 for teaching materials. This means that learning instruments using Treffinger learning model to improve the mathematical creative thinking ability of junior high school students are both valid in term of content and construct validity.

3.4 Implementing stage (Implementation)

The next stage was to conduct a pilot test (trial). This trial phase consisted of individual trial, small group trial, and field trial. Two criteria of practicality, namely: (1) experts and practitioners declare that the developed instruments can be applied, and (2) the developed instruments can be applied/implemented in the field [12]. Therefore, the learning instruments developed were categorized as practical or easy to implement as indicated by the results of field trials conducted for 30 Year 7 students and teacher responses toward the learning instruments. The observation aimed to examine the implementation of the learning utilizing the developed learning instruments using the Treffinger learning model to improve mathematical creative thinking ability. The analysis results of the learning implementation reported that the implementation of the learning reached to approximately 93%. This means that it is in the excellent category based on the specified criteria.

The data obtained from the teacher questionnaire was teacher general assessment on the developed learning instruments. Two junior high school mathematics teachers participated to complete the questionnaire. The analysis results indicated that the average of the mathematics teachers’ assessment of the lesson plan, student worksheet, teaching materials, and test of learning outcomes were 4.57, 4.56, 4.70, and 4.50, respectively, indicating that the assessment of learning instruments was at the excellent category based on predetermined criteria. To measure the practicality more accurately, the relationships between perceptions of teacher I and teacher II were also examined, followed by inter-rater test by calculating the kappa value. The kappa values were obtained using SPSS 23, the value of
teacher I and teacher II on the lesson plan, student worksheet, teaching materials, and test of learning outcomes were 0.462, 0.571, 0.545, and 0.600 respectively, indicating that the perception between the two teachers on the learning instruments was at the good category.

4. Conclusion

It can be concluded that the development process of learning instruments using Treffinger learning model to improve junior high school students' mathematical creative thinking ability consists of five stages; namely: analyzing, designing, developing, implementing, and evaluating. Furthermore, the results show that learning instruments developed are valid as indicated by the validator assessment results and the inter-rater test. Overall, the results indicate that the developed learning instruments satisfy the good criteria and all components in the learning instruments are consistent and support each other. The practicality test results are identified from the field trials results and teacher responses on the developed learning instruments, reporting an average of 93%. The analysis results of the response of two teachers fall into the excellent category. In addition, the inter-rater test also concludes that the perceptions between the two teachers are at the good category. For future research, we suggest to use the learning instruments developed in this research for further investigation such as comparing the conventional learning process with learning by using the Treffinger learning tool.

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