The development of learning tools using treffinger model assisted by geogebra to enhance students’ creativity

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Abstract. The development of the Treffinger model learning tools in enhancing the creativity of high school students assisted by GeoGebra software aimed to produce valid, practical and effective mathematics learning tools. This study was development research adopted the development model of Dick and Carey. The subjects were 22 Grade 11 students in one of the Islamic High Schools in Aceh. The data was the validation results and the results of the practical and effectiveness tests. Based on the validity test, the average scores of the lesson plan, student worksheet and test of learning outcome were 3.89, 3.82 and 3.55, respectively, indicating that the tools developed were valid. Based on the results of the pilot test, the practicality criteria were met based on the results of the observer's assessment of the learning implementation categorized as practical and the mean of the students' activities also satisfied practical criteria. The effectiveness criteria were also fulfilled based on the scores of the group worksheet and the scores of the student learning outcome test (meeting the minimum criteria of mastery learning). Hence, the learning tools developed were valid, practical and effective.

1. Introduction
Mathematics is a universal knowledge that underlies the development of modern technology and has an important role in a variety of disciplines. Mathematics as a human activity is a process of active, dynamic, and generative, as well as structured knowledge, develop critical thinking attitude, objective, and openness becomes very important for students to have in facing the ever-developing science and technology. Thus, a good mathematics learning tool is necessary so that the mathematics courses should be offered to all learners from primary schools to equip students with the ability to think logically, analytical, systematic, critical, and creative, as well as the ability to cooperate.

The computer-based learning will allow students to easily understand the abstract concepts [1]. Thus, the role of computers in mathematics is important, especially on the topics that requires two-dimensional images, such as three-dimensional graphics or curves, charts and others.

One software that can observe a complete understanding of the students is GeoGebra. GeoGebra is a mathematics computer program that can be used as a learning media for the material of functions and trigonometric functions. GeoGebra software is a computer program to teach students the concepts of geometry and algebra that are multi-representation, namely: 1) the algebra view, 2) the display graphics, and 3) the numerical display [2]. The three displays dynamically interconnected. This helps students learn abstract geometry and algebra objects. The learning
model is as a pattern or plan that has been planned in a way and used to develop the curriculum, organize the subject matter, and the members of her class instructions [3]. According to experts, there are several models of learning that can involve students in constructing knowledge in improving students' creativity. One of them is the Treffinger model. This model deals with creativity directly and gives practical advice on how to achieve integration [4]. By involving cognitive and affective abilities at every level of this model, Treffinger shows the mutual relationships and dependencies between them in encouraging creative learning.

In the learning process, the first level that should be applied is thinking skills. Teachers should stimulate students to think openly. The second level is that the teacher should concern in a manner that may expose students to more complex problems, which cause tension and stimulate students to show their creative potential in solving the problem. The third level is providing thinking problems involving students in a real challenge and encourage the use of creative thinking process until the students find their own solution of the given problems [5].

Creative thinking in mathematics is the ability to think mathematically. The level includes originality, elaboration, flexibility and fluency [6]. Creative thinking is a combination of logical thinking and divergent thinking which is based on intuition but still in consciousness [7]. Thinking activity can be defined as the ability to reflect the smoothness, flexibility and originality in thinking and the ability to elaborate, develop, enrich, detailing an idea [8].

This study aimed to develop learning tools with a valid, practical and effective Treffinger model applied in one of the Islamic high schools in Aceh, Indonesia.

2. Method

This study is Research and Development. It is functioned to produce a particular product and test the effectiveness of the product [9]. This study employed Dick and Carey model [10] with nine steps; (1) identifying learning objectives, (2) analyzing of learning objectives, (3) identifying the characteristics of students, (4) formulating learning objectives, (5) developing test items, (6) developing a learning strategy, (7) developing instructional materials, (8) conducting evaluations, (9) revising the learning tools. The procedures that will be carried out in the development of this learning tools are: (1) analyzing the needs, (2) determining the material, (3) identifying the learning syllabus, (4) developing the learning tools, (5) providing the test device that has been developed.

The research was conducted at one of the Islamic high schools involving five students for a small group test and 22 Grade 11 students for the bigger test. Data collection techniques used in this research was the validation sheet (lesson plan, student worksheet and test), observation sheet, questionnaire, and interview. The tests consisted of three short answer questions. Interviews were conducted on five subjects at the end of students' learning to know the response directly to the implementation of learning that has been implemented. The quality of learning tools developed refers to the material quality criteria, namely: (1) validation of content (relevance), (2) construct validity (consistency), (3) practicality, and (4) the effectiveness [11]. The indicators used to indicate that the validity of tools was the content and construct validity by the experts. The learning tool developed was said to be practical if experts and practitioners state that theoretically the learning materials can be tested in the field and the level of implementation was in a good category. Meanwhile, the effectiveness of the tools was seen from the results of student tests that must achieve a minimum mastery learning criteria score (75) [12]. The trials was conducted in three stages, namely:

- Evaluation of the second phase
  In this phase: (1) individual testing, the test is taken 5 students with backgrounds different achievements [10], (2) second revision, (3) small group trial, subjects used in this trial is 5 students with backgrounds different achievements [10], and (4) the third revision.

- Evaluation of the third phase
Before the learning media is tested at the stage of field trials, the test results are used as a learning device revision materials that will be used in the wider population. Subjects were taken on the field trial were the Year 11 students of one of Islamic high school in Aceh, Indonesia. In this trial, the learning was conducted using the tool with Treffinger models that have been developed.

3. Results and Discussion
The results of this study indicated the effectiveness of the administration of learning materials in the form of a lesson plan, student worksheet and learning outcomes tests. The first step in developing the administration of this learning material was to assess the situation in the classroom. In this stage, the developer made observations and interviews to examine whether the administration of learning materials was really needed in learning. The next stage was choosing the materials to be developed, namely functions and trigonometric graph functions. Functions and trigonometric graph functions are taught in Year 11. The lessons were one of the materials that were considered difficult for students to deal with, as stated by the teachers based on the results of interviews. Using the administration of Treffinger learning materials assisted by GeoGebra software is expected to help students understand learning more easily.

Before a device developed tested, validated prior learning devices using sheet validation by experts and practitioners. Quantitative data validation results by mathematics education experts and practitioners are tabulated in tables and then calculated the average score of all validators, as follows:

| Table 1. Results of the validation student worksheet |
| --- | --- | --- | --- |
| Aspect | Criteria | Validator 1 | Validator 2 | Validator 3 | Validator 4 | Validator 5 | Average per criteria | Average per aspect |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Contents | The content truth | 4 | 4 | 4 | 4 | | | 4 | |
| | Conformance task with indicators | 4 | 4 | 4 | 4 | 4 | | | 4 | |
| | Conformity with the Treffinger model task | 4 | 4 | 4 | 4 | 4 | | | 4 | |
| | The role of students' worksheets to improve students' mathematical creativity | 4 | 5 | 4 | 3 | 4 | | | 3.97 |
| | Compliance with the time allocation used | 4 | 4 | 4 | 4 | 4 | | | 4 | |
| | Eligibility in accordance with the learning device | 4 | 4 | 3 | 4 | 3.8 | | | 3.8 |
| Format | A clear division of material | 4 | 4 | 3 | 4 | 3 | | | 3.55 |
| | Interesting | 4 | 4 | 3 | 3 | 3.2 | | | |
| | Numbering system clear | 4 | 4 | 4 | 4 | 4 | | | 4 | |
| | Type and size of letters | 4 | 4 | 4 | 4 | 4 | | | 4 | |
| Language | Truth grammar | 4 | 4 | 4 | 4 | 4 | | | 4 | |
| | The simplicity of sentence structure | 4 | 4 | 4 | 4 | 4 | | | 4 | |
| | Clarity of instructions and directives | 3 | 4 | 4 | 4 | 3.8 | | | 3.95 |
| | Communication language used | 4 | 4 | 4 | 4 | 4 | | | 4 | |
| Average total | | | | | | | | | 3.82 |

The validity of the student worksheet was based on the analysis of the average total response (3.82), meaning that are in the valid criteria. The validation analysis results of the lesson plan is presented in Table 2.

| Table 2. Results of Validation Lesson Plan |
| --- | --- | --- | --- |
| Aspect | Criteria | Validator 1 | Validator 2 | Validator 3 | Validator 4 | Validator 5 | Average per criteria | Average per aspect |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
Table 2 show the validity of the lesson plan, with average score of 3.89, indicating that the validity of the lesson plan is on the valid criteria. The results of the validation analysis of learning outcomes tests are illustrated Table 3.

Table 3. Validation Results Learning Outcomes Test

| Aspect          | Criteria                                      | Validator | Average per criteria | Average per aspect |
|-----------------|-----------------------------------------------|-----------|----------------------|--------------------|
| contents        | Suitability indicators with aspects rated     | 2 2 2 2 3 |                      | 3                  |
|                 | The suitability of the problem with the treffinger model | 2 3 3 3 3 |                      | 3.5                |
|                 | Compliance with the language used to query   | 4 4 4 4 4 |                      | 4                  |
|                 | Compliance with grade level                  | 4 4 4 4 4 |                      | 4                  |
| Format          | Clarity of instructions for working Problems  | 4 4 4 4 4 |                      | 3.5                |
|                 | Completeness of scoring guidelines           | 3 3 4 3 4 |                      | 3.5                |
| Language        | Truth grammar                                 | 3 3 4 3 4 |                      | 3.7                |
|                 | The simplicity of sentence structure          | 4 4 4 4 4 |                      | 4                  |
|                 | Communicative language used                  | 4 4 4 4 4 |                      | 3.56               |

The results shows that the average of validity test for the learning outcomes was 3.56, meaning that questions have met the validity criteria.

Furthermore, the observations of student activity aimed to determine the implementation of learning by using Treffinger learning. The observation sheets used in educational research activities are usually in the form of teacher activity, student activities, and student development observation sheets [13]. Data observer ratings were analyzed using descriptive analysis of the percentage. The results of the observation data analysis are presented in Table 4.
Table 4. Analysis results of students activities observation

| No | Group | Lesson | Average |
|----|-------|--------|---------|
| 1  | I     | 1 88%  | 2 92%   | 3 88%   | 4 92%   | 90%    |
| 2  | II    | 1 92%  | 2 100%  | 3 88%   | 4 92%   | 93%    |
| 3  | III   | 1 88%  | 2 96%   | 3 84%   | 4 92%   | 91%    |
| 4  | IV    | 1 96%  | 2 92%   | 3 88%   | 4 92%   | 90%    |
| 5  | V     | 1 92%  | 2 92%   | 3 84%   | 4 80%   | 87%    |
|    | Total | 1 91.2%| 2 94.4% | 3 86.4% | 4 89.6% | 90.2%  |

Based on an analysis of student activities observation, student activities reached 90.2% for the four lessons, indicating that activities in the learning process is in a good criteria. This means that the activity of students in treffinger learning have already been well-developed. Next, the analysis results of the student worksheet are presented in Table 5.

Table 5. Analysis results of student worksheet

| No | Group | Value          | Average | Criteria |
|----|-------|----------------|---------|----------|
|    |       | Student worksheet 1 | Student worksheet 2 | Student worksheet 3 | Student worksheet 4 |         |         |
| 1  | I     | 100            | 92.5    | 95       | 87.5     | 93.7    | Good    |
| 2  | II    | 92.5           | 92.5    | 87.5     | 85       | 89.4    | Good    |
| 3  | III   | 100            | 100     | 90       | 85       | 93.7    | Good    |
| 4  | IV    | 97.5           | 92.5    | 97.5     | 85       | 93.1    | Good    |
| 5  | V     | 100            | 95      | 90       | 82.5     | 91.8    | Good    |

The analysis results of student grades on student worksheets presented in Table 5 show that the score of the student worksheet for all groups have reached a good criteria, meaning that students have been able to use and complete the developed worksheets properly.

Some conclusions obtained from the results of the interview are presented as follows:

- Students love learning with GeoGebra because some students felt that GeoGebra was easy to understand and fun. They also thought that through GeoGebra, they were more active and were challenged to learn because GeoGebra enable them to draw objects quickly and accurately. However, students also thought that if they used the software too often, then they might be able to forget the initial concepts that should have been used.
- Students' awareness of group learning also increased using GeoGebra. This can be seen from the responses of students in their efforts to help their peers in understanding the subject matter. Most students helped their group members to understand the material with a sincere intention to make it easy for their peers in learning so they could get good group grades. They also argued that if their friends did not understand the lesson, it might indicate that their group was not maximally successful.
- The obstacle faced by students in learning using this software was that teachers must have computer/laptop facilities that should be provided by the school. In fact, to date, students only co-shared the computers in a language laboratory and they can not use the laboratory continuously.
The indicator used to state that the implementation of the learning tools developed was practical if experts and practitioners state that theoretically it can be applied in the field and the level of implementation was in a good category. The implementation of learning materials developed was categorized as practical, as illustrated from the results of field trials involving 25 Year 11 students, where all students could use the learning tools properly, indicated by the percentage of student activities at the first lesson. The average student activities reached 91.2%, 94.4%, 86.4%, and 89.6 for the first to four lessons, respectively. The results of student and teacher assessments of the implementation of learning tools developed also indicated the good criteria. Based on the data from the field trial results, the implementation of learning tools developed need revising to improve the implementation of valid and practical learning tools.

The analysis results of student scores on student worksheet showed that average score for each group was 92.3, meaning that students could use and complete the developed student worksheet properly. The analysis results of the students test during field trials showed that the average for the learning outcomes tests was 75 after the learning through the strategy developed by researchers. However, it is equivalent to the value of the minimum criteria of mastery learning.

4. Conclusion

The validity of the learning tools was based on the validator assessment analysis, indicating a very valid criterion. Hence, the learning tools developed was valid based on several aspects; the content which was according to the syllabus, the construct that was according to the characteristics or principles of learning as well as each component on the tools was consistent and mutually supportive, and the language which was accordance to applicable language rules of bahasa. The final product was valid, practical and effective learning tools. Based on the validity test, the total average for the lesson plan, student worksheet and achievement test was 3.89, 3.82 and 3.55, indicating that the tools developed were valid. Based on the results of the trial, the practicality criteria were met based on the results of the observer's assessment of the implementation of learning and the average of the students' activities showing practical criteria. On the contrary, the effectiveness criteria were fulfilled based on the scores of the student worksheet group and the student learning outcomes test at the minimum criteria of mastery learning. Hence, the learning tools developed were valid, practical and effective.

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