The development of algebra teaching materials to foster students’ creative thinking skills in higher education

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Abstract. Students’ creative potential must be developed. The purpose of this study is to develop algebra teaching materials to foster students’ creative thinking skills at universities that are valid, practical and effective. The model of Plomp was used in this study that consisted of several stages including validation by experts, validation by practitioners and field trials. Based on the validation results, the algebra materials were valid. While from the observation results, the implementation test was considered practical and effective. Thus, algebra teaching materials can be used by lecturers in algebra courses in the mathematics education department in higher education.

1. Introduction
Every individual has natural ability to think creatively. This ability needs to be developed otherwise it will only be an inactive potential. Creative potential of an individual will be latent if not developed and formed [1,2]. The ability of creative thinking can also be referred to as divergent thinking [3]. Fong [4] said that creative thinking is a capability based on available data or information to find many possible answers to a problem where the emphasis is on the quantity, usability and diversity of the answers. Creative thinking can also be interpreted as a combination of logical thinking and divergent thinking based on conscious intuition [5].
Creative thinking is both authentic and reflective and produces a complex product [6,7]. The ability to think involves the activities of synthesizing ideas, building new ideas and determining their effectiveness. It also involves the ability to make decisions and produce new products. Creative thinking can be indicated as (1) a product of mental activity that has novelty and subjective value subjectively and objectively; (2) process of new thinking, i.e. transforming an initial idea and deciding whether to receive or to reject it; (3) the thinking process is characterized by a strong and stable motivation, and can be observed over time with high intensity [7,8,9]. The ability to think creatively like this is very important in learning mathematics, especially in problem solving.

The development of students’ creative thinking is very important in the era of global competition considering the level of complexity of problems in all aspects of modern life is higher [10]. Creative thinking needs to be developed through active and creative learning, in order to guide students to practice solving problems from different perspectives so that they are able to deal with complex situations in their surrounding community [11,12]. To promote creative thinking, Kandemir suggested that the learning applied by teachers should be oriented to creativity that invites students to find their own solutions from various angles of view, the goal is to train the ability to think [2].

Basic thinking skills in learning mathematics are usually formed through activities that are convergent, that is the process of seeking the single most appropriate answer. These activities generally tend to be algorithmic, mechanistic, and routine. While the ability to think is divergent creative process to various directions and generates many alternative solutions [13]. The ability to think creatively can be useful for dealing with possibilities, and this ability has the characteristics most likely to be developed through mathematics learning [14,15,16]. Therefore, teachers who teach mathematics are expected to be able to help students in developing reasoning, logical thinking, logical systematic, creative, intelligent, sense of beauty, open attitude and curiosity. The success of learning, especially in developing students' creative thinking ability, is also very dependent on the teaching materials used.

Teaching materials are a set of learning resources that enable students and teachers to do learning activities [17,18,19]. The materials are systematically arranged to create an environment or atmosphere that allows students to learn independently, critically, creatively, and analytically [18]. One of the teaching materials that is intended in this study is algebra teaching materials used in linear algebra and elementary algebra courses for students at the mathematics education department in higher education.

Algebra is a branch of mathematics that deals with properties of operations and the structures which these operations are defined on [20,21]. The Elementary Algebra Course follows the study of arithmetic. This course is mostly preoccupied with operations on sets of whole and rational numbers and solving first and second order equations [22]. Algebra is a suitable subject to train students’ creative thinking skill. Therefore, this study aimed at developing teaching materials that support students’ creative thinking, because so far there has been no similar research conducted for a special college level on the development of algebra teaching materials in college.

The development of the teaching material was based on the development of the digital era today, where students were required to be able to be creative in dealing with real problems. Creativity is a manifestation of creative thinking ability. Therefore, the researchers were interested in conducting research by developing algebra teaching materials for elementary algebra courses that could foster students' creative thinking skills in higher education.

2. Method
The type of this research was a development research with reference to the development model developed by Plomp. The development steps consisted of (1) Preliminary research, (2) Prototyping phase and (3) Assessment phase. The research was conducted at three departments of mathematics education in Universitas Malikussaleh, State University of Malang and Wisnuwardhana University. The participants were 12 students from each university who were enrolled in the odd semester of the 2017/2018 academic year. The students came from a class with heterogeneous ability. The research
also involved Algebra lecturers at the university who acted as observers for the implementation of the algebra teaching materials.

The quality criteria of the algebra teaching materials included valid, practical, and effective aspects. After the algebra materials were validated, they were then tested on the students at the Mathematics Education Department of Malikussaleh University. The types of data collected in this study were qualitative and quantitative. The qualitative data were obtained from the feedback and suggestions from validators and students. The quantitative data were obtained from the scores of test of students achievement.

Data analysis used descriptive qualitative and descriptive quantitative methods. Data analysis was performed to process the data from validation sheet, observation sheet, student response sheet and student ability test. The data were in the form of scores on the student's student validation sheet, observation sheet, student response questionnaire and the students’ test results. The results of this analysis were used to determine whether the algebra teaching materials met the valid, practical, and effective criteria.

3. Result and discussion

3.1. Result of preliminary research phase

The algebra teaching material was developed using Plomp development research design which consisted of 4 stages: preliminary research phase, prototyping phase, assessment phase and dissemination phase. In this study, the dissemination phase was not conducted due to time and financial constraints. At the preliminary stage, the research group conducted direct observations at several departments of mathematics education in Indonesia including Universitas Malikussaleh, State University of Malang, Wisnuwardhana University, STKIP Bina Bangsa Meulaboh, Islamic University of Darul Ulum Lamongan, Kediri Polytechnic, Madura University, Serambi Mekah University and Samudra University.

During this phase, it was deduced that students’ creative thinking skill was low with the average score below 60. Additionally, it was also found that students’ motivation in learning algebra was also low and the availability of algebra books was limited. Based on these data, the researchers conducted this study in order to produce algebra teaching materials that could foster students' creative thinking skills in higher education. At this phase, the researchers designed plans and collected the materials to be organized into algebra teaching materials for the Elementary Algebra Course. The materials included content material, worked examples and exercises.

3.2. Result of prototyping phase

At the prototyping phase, the algebra teaching materials were validated by two professors of mathematics. Figure 1 shows a comment from one of the validators.

![Figure 1. Validator’s comment.](image)
As shown in figure 1, the validator suggested revising the algebra problem because it did not promote students’ creative thinking. Based on this comment, the researchers revised the problem. Figure 2 shows the result of the revision.

![Figure 2. Result of revision.](image)

The algebra teaching materials was revised three times in accordance with the comments of the validators. Finally, the validation result for the final revision was 82.15%, so it could be established that the algebra teaching materials were valid because the result was more than 70%.

3.3. Result of assessment phase

Trials were conducted to assess the practicality and effectiveness of the algebra materials. The trials were conducted at three departments of mathematics education in Universitas Malikussaleh, State University of Malang and Wisnuwardhana University. Each trials involved 12 students. The trials covered eight topics which were conducted in eight class meetings and one meeting for final test.

The class meetings ran from October 3, 2017 to December 23, 2017. During the class meetings, two observers were present in the classroom. The purpose of the observation was to observe the implementation of the algebra materials and activities in the class in using the algebra materials. Based on the results of field observations, the level of the implementation was in high category with the average score of 86.13%. Therefore, it could be concluded that the algebra teaching materials met the criteria of practicality.

Based on the results of the test of creative thinking skills and students’ mastery of the learning content, the average score was 87.25%. Therefore, it could be concluded that the algebra teaching materials met the criteria of effectiveness.

3.4. Discussion of final product

The algebra teaching materials could be considered feasible if they met the criteria of validity, practicality, and effectiveness. The validity test measured the instruction, content, construction, conceptual, and language aspects. Based on the validation result of the algebra teaching materials, the average value was 82.15%. Accordingly, the algebra materials were included in valid criteria.

The algebra teaching materials met the criteria of practicality if the implementation was more than 70%. Data obtained from the observation showed that the average value of the implementation of the materials was 86.13%. Thus, the materials could be said to be practical.

The algebra teaching materials could be categorized effective if 75% of the students passed the final test. The data obtained from the test results of creative thinking skills showed that 87.25% students passed the test. Thus, it could be concluded that the algebra teaching materials were effective.

There were three aspects of learning mastery indicators on the algebra teaching materials: (1) creative thinking ability test as well as algebra content mastery test, (2) competency test and (3) group work result. All these indicators were achieved. Therefore, it could be concluded that algebra teaching materials were valid, practical, and effective.
Based on the result, it could be stated that the algebra teaching materials could be used by lecturers of mathematics in Indonesian universities because they have fulfilled the criteria of validity, practical and effectiveness. Nevertheless, not all learning methods are applicable with the algebra teaching materials that we developed. This study was limited to product design, it did not cover dissemination. This gap allows other researchers to conduct study on the materials’ time effectiveness, suitable learning methods and more.

4. Conclusion
Based on the research, it could be concluded that the algebra teaching materials to foster students' creative thinking ability in higher education were feasible to use because they were proven valid, practical, and effective. The average value of the validity was 82.15%. Thus, the algebra teaching materials can be used without further revision. The average value of the practicality was 86.13%. The average score of the effectiveness test 87.25%. Therefore, the conclusion of this research was that the final product of algebra teaching materials had fulfilled the valid, practical, and effective criteria.

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