Development of mathematics learning tool based on open-ended with jumping task and the effects on creative thinking ability of junior high school students

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Abstract. This study aims to develop a learning tool based on open-ended with jumping task on the material of the system of linear equations in a two variable for grade VIII junior high school students and to determine the effects on students' creative thinking ability. This research was mixed method, which combines qualitative research and quantitative research. The development model used in this research is Thiagarajan which goes through four stages, namely define, design, develop, and disseminate. Meanwhile, for experimental research using quasi experimental design, namely pretest-posttest for non equivalent control group design. The subjects of this study were students of Islamic Junior High School Wahid Hasyim Balung. Two classes were selected as the research sample, class 8A as the experimental class and class 8B as the control class. Students' creative thinking abilities were measured using tests of creative thinking ability. The results showed that learning tool based on open-ended with jumping task met the criteria of validity, practicality, effectiveness, and had a significant effect on students' creative thinking ability.

1. Introduction
In the 21st century, the learning process aims to enable students to master critical, creative, innovative thinking skills, as well as communication and collaboration skills [1][2]. This is in line with the opinion of [3] that the ability to think creatively is one of the ability students must have in learning mathematics. In today's global era, it is very important to train creative thinking skills as students' intelligence in facing global competencies [4][5]. At the school level, the ability to think creatively is usually associated with problem posing and problem solving [6][7][8], because in applying mathematical procedures mathematical creative thinking involves cognitive processes. With a variety of solving methods, students' creative thinking skills will improve [4][9]. Creative thinking is a form of thinking that refers to the capacity to produce new solutions or innovative ideas in the course of problem solving [7][10]. Mathematical creativity is the abilities to solve problems in a multitude of different ways [11]. The role of the teacher is required to improve the creative thinking skills of students through learning experiences, considering the importance of creative thinking skills for students.

One of the attempts to develop students' creative thinking skills is by presenting students with open-ended problems. Using open-ended problems in mathematics learning will enhance students' creative thinking skills [4][12][13][14]. Open-ended problems can make students go beyond the usual way, because students are motivated to look for correct and different answers with various solutions. Open-ended problems are designed in such a way that there is more than one correct answer or various
solving strategies [15], so that it will be challenging students in various cognitive development [16]. In order to develop their comprehension and creative thinking abilities, students must have the skills to solve non-routine or open problems [8][14].

Learning in the latest revised 2013 curriculum emphasizes on using Higher Order Thinking Skills (HOTs). One of the main parts of learning using HOTs is jumping tasks [17]. The jumping task method is to provide tasks or questions that are above the curriculum's/ challenging demands [18] and the development and implementation of the main concepts [19]. In Japan jumping tasks are the main part of learning using high-level skills (HOTs). The use of jumping tasks in learning can help student to develop higher order thinking skills [20][21]. Students with low ability have difficulty solving jumping task questions, but with collaborative learning students are able to solve jumping task questions [1].

The system of linear equations in a two variable equation is one of the 8th grade math content. Based on interviews results of Islamic Junior High School teacher of Wahid Hasyim Balung, it clearly known that: students still have difficulty making mathematical models of the problems given, students find it difficult if given different questions than the teacher exemplifies, student worksheets only contain question exercises, and students do not have a sense of care for friends who do not understand because they think individually.

It is important to perform special research on the development of learning tools focused on open-ended jumping tasks and their effect on the creative thinking ability of junior high school students, based on the previous introduction.

2. Research Methods

This study used a mix method research that combines two studies, those are the 4-D Thiagarajan model development research and experimental research. There are four phases in the 4-D Thiagarajan model which are definition, design, development and disseminate [22]. The learning tool developed in this study are the lesson plan, student worksheets and creative thinking skills tests.

The development for this research was carried out at Islamic Junior High School Wahid Hasyim Balung Jember in class VIII C. The data collection in this study were validation of experts, observation of students' creative thinking ability tests and student response questionnaires. The following are the details in the research data, which are as follows.

| Table 1: Research data |
|-------------------------|
| **Data**               | **Data collection**                                                   |
| **Validity**           | Learning tool is said to be valid if it comply validity criteria. Validity was carried out by 2 lecturers of Faculty of Mathematics and Natural Sciences, University of Jember and 1 mathematics teacher at Islamic Junior High School Wahid Hasyim Balung Jember. |
| **Practicality**       | Learning tool is said to be practical if the observation sheet comply practical criteria. Data were obtained through observation sheet on the implementation of learning tool and interviews' results. |
| **Effectiveness**      | Learning tool is said to be effective if it comply 3 aspects that are cognitive seen from the test result, psychomotor seen from student activity observation sheet, and affective seen from student response questionnaire. |
| **Creative Thinking Ability test** | Learning tool said to have an effect on students' Creative Thinking Ability if they comply criteria of assessment of creative thinking level |

Population in this study was class VIII which consisted of 5 classes. Two groups, experimental and control classes, who were taken randomly using the cluster random sampling method. In Table 2 below the experimental research design in this research can be seen.
Table 2: Research Design Scheme

|                  | Experimental class | Control Class |
|------------------|--------------------|---------------|
|                  | $O_1$ X $O_2$      | $O_2$ $O_4$   |

Explanation:
$O_1, O_2$ : Pretest
$O_3, O_4$ : Posttest
X : Treatment

Data analysis on students' creative thinking ability includes different levels based on aspects of fluency, flexibility, and novelty [2][23][24]. The normality and homogeneity assumption tests are carried out first before the data is analyzed.

3. Results and Discussion

Development Research

This research generates learning tool that are valid, practical, effective, and can be used to see their effect on students' creative thinking ability. The process of developing learning tool based on open-ended with jumping tasks begins with the defining stage, after obtaining data about the student's condition, then proceeding to the design stage. After the design stage is complete, it is then continued with the development stage. At the development stage, the assessment data were obtained on the validation sheet carried out by three validators. After the learning tool is said to be valid, then a test is carried out on the students, but if it is not valid, then revisions are made according to the suggestions and input from validator. Results of the assessment from three validators, that is mathematics learning tool developed by each of them meet the valid criteria, so that the tool is ready for use by researchers. Results of validation data analysis of the lesson plan, student worksheets, and tests of creative thinking ability of the three validators can be seen in Figure 1.

The data analysis of practicality in this study used an observation sheet. Practicality criteria can be seen from results of analysis of the observation sheet on the application of learning tools. At the first meeting, the percentage of application of learning tools was 81.8% for a good category. At second meeting the percentage of learning tool implementation was 89% with a good category and at third meeting the percentage of learning tool implementation was 94.5% with a very good category. So that each meeting shows the percentage of learning device feasibility is in the good and very good category. The observation data on the implementation of learning tool can be seen in Figure 2. In addition, practicality is also seen from the outcomes of student interviews to find out the obstacles or problems experienced by students while engaging in learning and using student worksheets, so that the learning tool developed can be identified with the obstacles. The following is an example of an interview result with one student to know how student’s respond to the learning process and the tools used and what difficulties are faced during the learning process.

Researcher : What do you think about the learning that I applied?
Student : I think the learning was fun, because by studying in groups I could discuss with my group members and if I find difficulties, I can ask to my group members who have already understood.

Researcher : What do you think about the students worksheet that I gave?
Student : It looks quite interesting, has pictures and is colorful.

Researcher : Does the students worksheet that I provide can help you to understand the system of linear equations in a two variable material?
Students : I feel helped in understanding the material because in the students worksheet, there are steps that guide me.

Researcher : What difficulties did you get in carrying out the students worksheet and tests that I gave?
Student: Because the questions given were open-ended questions, sometimes I found it difficult to find more than one possible answer and have to be different from other friends and I found it difficult to find new ways.

After learning using open-ended based tools with jumping tasks, it was understood that students had no difficulty using open-ended student worksheets with jumping tasks, based on the results of student interviews. So it can be concluded that learning tool developed meet practical criteria.

Next step is to analyze the effectiveness of the tool, which is obtained from results of creative thinking skills test, student activities and student response questionnaires. Test was attended by 23 students in the class and gave results that 19 students completed and 4 other students did not complete. Completeness of scores above minimum completeness criteria reaches 82.8% of all students in the class. Student activity data were obtained from observations in each group. Student activity at the first meeting got a score of 70% with active category, the second meeting got a score of 78% with active category and at the third meeting got a score of 90% with very active category. Meanwhile, student response questionnaire data obtained from 23 students showed that 83% of students responded positively. It can therefore be inferred that the learning tools developed fall under the effective category. Student activity data and student response questionnaires will be shown in Figure 3 and Figure 4 below.

![Figure 1. Result of analysis validation](image1)

![Figure 2. Observation results of learning tool implementation](image2)

![Figure 3. Data of Student Activity](image3)

![Figure 4. Data of Student Response Questionnaire](image4)
**Experimental Research**

Two classes, the experimental class and the control class, were used in the experimental research. Experimental research using a quasi experimental design, namely pretest posttest for non equivalent control group design. Experimental class is a class that uses open-ended learning tool with jumping tasks that meet the valid, practical, and effective categories, while control class uses conventional learning that is commonly applied in schools. A pre-test was performed at the beginning of learning and a post-test was conducted at the end of learning. Pre-test and post-test used were questions about the ability to think creatively.

Research data obtained through pre-test in experimental class obtained an average of 47.68. Meanwhile, the control class obtained an average pre-test of 47.25. After experimental class was treated with learning tool based on open-ended with jumping tasks, the average post-test result was 77.39. Whereas an average post-test of 53.04 for the control class using traditional learning tools obtained. This shows a significant contrast between experimental class and the control class. The Kolmogorov Smirnov test was then used to determine whether the outcomes of the pre-test and post-test were normally distributed. The findings of the Kolmogorov-Smirnov test are presented below.

| Table 3. Normality Test |
|-------------------------|
| Class                   | Kolmogorov-Smirnov^a |
|                         | Statistic   | df | Sig.  |
| creative abilities test | Experiment Pretest | .174 | 23 | .068 |
|                        | Experiment postest | .178 | 23 | .057 |
|                        | Control pretest   | .172 | 23 | .077 |
|                        | Control postest   | .168 | 23 | .091 |

On the basis of the above table, it can be inferred that the data used is normally distributed according to the basis for the decision-making of the normality test, namely if the Sig> 0.05 is normally distributed. So it is possible to use the independent sample t-test to test the data.

| Table 4. Independent Samples Test |
|-----------------------------------|
| Levene's Test for Equality of Variances | t-test for Equality of Means |
| F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference |
| Creativity Abilities Test (postest) variances assumed | 2.264 | .140 | 13.427 | 44 | .000 | 24.348 | 1.813 | 20.693 | 28.002 |
Based on the findings of quantitative data analysis, the creative thinking ability of students in the experimental class were better than in the control class. This is because the learning experiment class uses open-ended tool with jumping tasks that have been developed previously, while control class uses student worksheets provided in the school. Learning activities in the experimental class were carried out by collaborating between students and forming groups of 4 students. Learning is implemented in several stages, those are orientation, open problems presentation, working on open problems individually, group discussions on open problems, presentation of group discussion results, and conclusions. Whereas in control class, conventional learning is carried out where the teacher is the center of learning using the tools provided by the school.

At the beginning of learning, students are given open problems for them to solve which will later lead them to find a system of two variable linear equations concept. In constructing a system of two-variable linear equations concept, students are first guided to think individually and then interact in groups of peers. Students actively discuss and ask and answer each other in solving the problems contained in the student worksheets. If there are students who still don't understand, then they will ask their group members who already understand, and students who already understand they help their friends who don't understand so that no student is neglected. In the following figure, the discussion activity in groups is presented.

![Figure 5. Student activities in experimental class](image)

**Figure 5. Student activities in experimental class**

**Description:**

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- : Discussion Interaction  
- : Student answering / explaining  
- : Student asking

The group discussion is presented in the following figure when in the control class.
In experimental class group discussion activities went quite well. It can be shown that students asked each other questions and gave answers in the experimental group. Giving questions about jumping tasks that trigger them to discuss and interact with each other. This is in line with the opinion of [1][25] that giving jumping tasks will train students to grow and develop with each other and be able to create learning activities such as interaction, dialogue, and cooperation between students. Meanwhile, the group in the control class, S7 and S8, meanwhile, did not understand the content, but they were hesitant to ask questions and only in S5 and S6 did the conversation take place. Besides that, S9 in group 2 gave answers to all members of their group without explaining. Without knowing the answer, other students only copy S9's answer. Overall students, group discussions in experimental class showed that students were able to collaborate with their peers. Meanwhile, discussion that took place in control class only aims to answer the problems while ignoring colleagues in one group who has understand or has not.

Descriptions of answers and interviews with students are needed in this study to measure students' creative thinking skills by fulfilling 3 indicators, those are fluency, flexibility, and novelty. Fluency can be fulfilled if students can solve given given smoothly and correctly and come up with many ideas about a problem according to the information provided. Flexibility can be fulfilled if students can trigger problem solving with various solving strategies. Novelty is fulfilled if students can trigger different problem solving from other students.

Adapun jawaban siswa yang memenuhi ketiga indikator keterampilan berpikir kreatif pada gambar berikut adalah sebagai berikut.
In Figure 7 above, we can see that these students can determine 3 possible flour and sugar that Desi can buy for Rp. 60,000. Based on this, these students were able to fulfill the fluency aspect. This is in accordance with [2][4] that the aspect of fluency can be seen when students can provide various possible answers.
In Figure 8 we can see that the student solved the problem given using 3 different ways, namely substitution, elimination and addition. So that we can conclude that the student has met the flexibility aspect. This is in accordance with [2][4] that the flexibility aspect is said to have been reached by students as they are able to solve problems using a variety of diverse methods of solving them.

In Figure 8 we can see that the student used substitution method and elimination-substitution method to find the price of 1 kg of flour and 1 kg of sugar. In addition, he also uses another method, that is addition. Student pays attention to the constants in each equation, there are \(4x + \frac{1}{2}y = 18000\) and \(2x + 3y = 42000\). By adding up 18000 and 42000 obtained 60000. From this result student had an idea that 60000 is corresponding to the money Desi had. Therefore, the student immediately adds two known equations to obtain a new equation, that is \(6x + 3.5y = 60000\). From this equation the student concluded that with Rp. 60000, Desi could buy 6 kg of flour and 3.5 kg of sugar. The student argues that in this solution step it was not necessary to know the price for each 1 kg of flour and sugar. So it can be concluded that these students have fulfilled the novelty aspect. This corresponds to [2] that students can be said to fulfill the novelty aspect if students can write down answers and solutions that look different from what has been taught in class.

Several other researchers have developed an open-ended learning tool for mathematics, in this research, an open-ended learning tool combined with a jumping task. This research method is also intended to assess the effect of students' creative thinking skills on problem-solving. The association between open-ended and jumping tasks to demonstrate their effect on creative thinking skills is seen in the following figure.
Development of this learning tool has advantage of using an approach in delivering material and students are trained to think at higher levels with jumping task. In addition, this research will also analyse the effects of students' creative thinking abilities. Unlike prior research [5][26].

4. Conclusions
Based on research that has been done, it can be inferred that the development of learning tool based on open ended with jumping task complies valid, practical, and effective categories. Development process uses Thiagarajan 4-D model, those are define, design, develop, and desseminate. Data is normally distributed on the basis of the Kolmogorov-Smirnov test. Sig value on Levene's test for equality of variances is 0.140 > 0.05, so the data is homogeneous. Sig value (2-tailed), that is 0.000 (< 0.05), such that H₀ is rejected and H₁ is accepted. Therefore, learning tool of open-ended with jumping task have an effect on students' creative thinking ability.

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References
[1] Hobri, Ummah I K, Yuliati N and Dafik 2020 The effect of jumping task based on creative problem solving on students’ problem solving ability Int. J. Instr. 13 387-406
[2] Sa’Dijah C, Handayani U F, Sisworo, Sudirman, Susiswo, Cahyowati E T D and Sa’Diyah M 2019 The Profile of Junior High School Students’ Mathematical Creative Thinking Skills in Solving Problem through Contextual Teaching Journal of Physics: Conference Series 1397
[3] Hobri, Oktavianingtyas R, Trapsilasawi D, Murtikusuma R P and A’Yun Q 2020 Analysis of students’ critical thinking skills on social arithmetics with jumping task Journal of Physics: Conference Series 1465
[4] Titikusumawati E, Sa’diah C, As’ari A R and Susanto H 2019 An Analysis of Students’ Creative Thinking Skill in Creating Open-Ended Mathematics Problems through Semi-Structured
Problem Posing. *Journal of Physics: Conference Series* **1227**

[5] Hobri, Nazareth E, Romlah S, Safitri J, Yuliati N, Sarimanah E, Monalisa L A and Harisantoso J 2019 The students’ creative thinking ability in accomplishing collaborative learning-based open-ended questions *IOP Conference Series: Earth and Environmental Science* **243**

[6] Siswono T Y E 2010 Leveling Students ’ Creative Thinking in Solving *IndoMs JME* 1 17-40

[7] Nadjafikhah M, Yaftian N and Bakhshalizadeh S 2012 Mathematical creativity: Some definitions and characteristics *Procedia - Social and Behavioral Sciences* 31 285-291

[8] Novita R and Putra M 2016 Using Task Like Pisa’s Problem to Support Student’s *J. Math. Educ.* 7 31-42

[9] Lince R 2016 Creative Thinking Ability to Increase Student Mathematical of Junior High School by Applying Models Numbered Heads Together *J. Educ. Pract.* 7 206-212

[10] Hadar L L and Tiros M 2019 Creative thinking in mathematics curriculum: An analytic framework *Think. Ski. Creat.* 33

[11] Permatasari S D A, Budiyono B and Pratiwi H 2020 Analysis of mathematical creativity in the field of geometry in junior high school students *Journal of Physics: Conference Series* **1469**

[12] Wijaya A 2018 How do open-ended problems promote mathematical creativity? A reflection of bare mathematics problem and contextual problem *Journal of Physics: Conference Series* **983**

[13] Agustianingsih R and Mahmudi A 2019 How to design open-ended questions? : Literature review *Journal of Physics: Conference Series* **1320**

[14] Siswono T Y E 2008 Promoting Creativity in Learning Mathematics using Open-Ended Problems *3rd Int. Conf. Math. Stat.*

[15] Suyitno A, Suyitno H, Rochmad and Dwijanto 2018 Use of open-ended problems as the basis for the mathematical creativity growth disclosure of student *Journal of Physics: Conference Series* **983**

[16] Munroe L 2015 The Open-Ended Approach Framework *Eur. J. Educ. Res.* 4 97-104

[17] Saskiyah S A and Putri R I I 2019 Jumping task using the context of kain jumputan on the fractional operation *Journal of Physics: Conference Series* **1315**

[18] Sugiarso, Susanto and Irvan M 2018 An analysis of students’ metacognition ability through jumping task strategy to solve geometry problem. *Int. J. Adv. Res.* 6 1375-1381

[19] Fatimah I, Hendayana S and Supriatna A 2018 Didactical design based on sharing and jumping tasks for senior high school chemistry learning *Journal of Physics: Conference Series* **1013**

[20] Putri R I I and Zulkardi Z 2019 Designing Jumping Task on Percent using PMRI and Collaborative Learning *Int. J. Emerg. Math. Educ.* 3 105-116

[21] Hobri, Septiawati I and Prihandoko A C 2018 High-order thinking skill in contextual teaching and learning of mathematics based on lesson study for learning community *Int. J. Eng. Technol.* 7 1576-1580

[22] Lawhon D 1976 Instructional development for training teachers of exceptional children: A sourcebook *J. Sch. Psychol.* 14 75

[23] Siswono T Y E 2011 Level of student’s creative thinking in classroom mathematics *Educ. Res. Rev.* 6 548-553

[24] Fauziah E W, Hobri, Yuliati N and Indrawanti D 2019 Student’s Creative Thinking Skills in Mathematical Problem Posing Based on Lesson Study for Learning Community *IOP Conference Series: Earth and Environmental Science* **243**

[25] Nofrion N 2017 Improving student learning activities through the implementation of the jumping task method in geographic learning *J. Geogr.* 9 11-20

[26] Anwar N, Johar R and Juandi D 2015 Development of learning tools based on an open ended approach to improve junior high school students' mathematical creative thingking skills *J. Didakt. Mat.* 2 52-63