THE DEVELOPMENT OF MATHEMATICS *OPEN-ENDED* PROBLEMS IN CIRCLE MAIN TOPIC FOR JUNIOR HIGH SCHOOL

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Abstract

The development of students' creativity in solving problems can be increased by giving open-ended problems which has multiple answers and multiple ways to get sollution. The purpose of this research is to develop the valid, practicable, and efective open-ended problems in circle main topic for junior high school. The type of this research is the Research and Development (R&D) using Tiagarajan's 4D model without the implementation phase. This research involves three main phases: 1) define, 2) design, and 3) develop. The develop phase is consist of three steps, those are the expert validation, limited test, and field test. This study has been conducted on VIII grade students of a Junior High School in Bengkulu City on second semester of 2012/2013 academic year: 32 students for limited test, and 132 students for field test. Based on the expert validation, limited test, and field test, the result of this development is the the valid, practicable, and efective open-ended problems in circle main topic for Junior High School. From the study, can be conclude that those open-ended problems can be used for developing the junior high school students' creativity.

Keywords: mathematics, Research and Development (R&D), open-ended problems, circle.

INTRODUCTION

The rapid developments in science and technology affect human life. Economy, government, industry, lifestyle, also the human mindset also improved rapidly. In this modern era, every one need to be creative and open minded in receive and take an act on this improvement of sciences and technology.

Mathematics as a science major that gives a big influence on the development of science and technology also continues to improve rapidly, so does the learning of mathematics. Various strategies and creative learning and innovative approaches were being developed. To improve their creativity, students need to get learning activity which can train and fasilitate them in giving idea freely.

Mathematics learning today generally still use closed questions that the answers and the steps are fixated on what is exemplified by the teachers. Ruseffendi (2006) argues that in traditional mathematics teaching students immitated the pattern and ways to solve the problems which had been taught by their teacher. Students are comonly not given the oportunities to initiate their own ideas and ways for solving the problems. As a result, according to Hudojo (1990) the creativity, comprehension and concepts understanding get into a very shallow place, because just concern on learning outcomes which are isolated by ignoring the learning process. Finally, mathematical and creative thinking skills that should be the goal of learning were not achieved.

Questions used in the study should be able to improve a good understanding of the students. Problem is not just aiming to assess the results, but also the process of obtaining these results. It also needed to have problems that can stimulate students' mathematical thinking, active, and creative. Problem is most appropriate to obtain all of it is open-ended problems that have more than one correct answer to the solution is more than one way of settlement. Shimada (in Becker & Shimada, 1997) said that open-ended problems are problems that are formulated to have multiple correct answers. *The open-ended* approach can provide an opportunity for students to gain knowledge and experience of finding, identifying, and solving problems by their own techniques according to their own abilities.

Pelfrey (2000) said that *the open-ended* problems reference to problems that have more than one correct answer and more than one strategy in acquiring answer. According to Becker & Shimada (1997, in Capraro),*open-ended* problems is a matter in which the purpose is not stated explicitly in its sentences, thus requiring students to build their own specific objectives to work. An open-ended problems by is a matter that has been formulated to have many correct answers(Darmasya, 2012). O*pen-ended* approach by Takahashi is an instructional approach using *open-ended* problems, which have many solutions or approaches to many solution. Nohda (2000) said that the purpose of the open approach in teaching is to develop students' creative activities and their mathematical mindset in solving problems simultaneously.

According to Toshio Sawada (in Becker &Shimada, 2009), *open-ended* problems can be classified into 3 types, those are: type 1. *Finding relations: Students are asked to find some mathematical rules or relation*s; type 2. *Classifying:* Students are asked to classify according to different characteristics, which may lead them to formulate some mathematical concepts; and type 3. *Measuring:* students are asked to assign a numerical measure to a certain phenomenon. Problems of this kind involved several facets of mathematical thinking. Students are expected to apply mathematical knowledge and skills they have previously learned in order to solve the problems.
With *open-ended* problems, students can become more creative in solving problems, because the completion of the way and answer questions not fixated on any single solution. High ability students can be freer to develop their knowledge, while the low-ability students can still use the knowledge that he had to obtain a solution. Some researches have shown that learning with open-ended approach can improve the students' creative thingking.

Usually the teachers have not been using the questions *open-ended* in the learning of mathematics. This is because teachers usually only provide the question from the available textbooks and teaching materials on that still use closed questions. Based on observations and interviews with mathematics teachers in one of junior high school in Bengkulu City, it was known that teachers still use the questions provided in the textbook. The questions in the textbook are still close questions. Because of that, the students are not familiar and they do not tend to like the contextual problems about the application of mathematics in everyday life.
The circle is one of figure which frequently encountered in everyday life. Learning material about circle requires imagination and creativity in understanding the concept, especially on materials related to the everyday life problems that demand an open and

creative thinking from different perspectives. The required *open-ended* problems in mathematics learning to develop students' creative thinking had not been used and had not been developed by teachers.
Therefore, researchers tried to develop mathematics *open-ended* problems in circle main topic for junior high school. The problems that developed in this study are the problems that have many correct answers and many ways of sollutions. This research was expected to produce some *open-ended* problems that can be used by teachers to train students' creative thinking as well as can be a motivation and guidance for teachers in developing an open-ended problem.

The main research question in this study is: How do the results of the development of the questions *open-ended* in circle main topic for junior high school are valid, practical, and effective? The aim of this research is to generate the *open-ended problems of* circle main topic for junior high school which are valid, practical, and effective.

METHOD

The method of this research is the Research and Development (R&D) using Tiagarajan's 4D model without the implementation phase. Research and development *(R&D)* is a method to develop a new product or improve an existing product, which can be accounted (Sukmadinata, 2008). Products developed in this study are the *open-ended* problems in circle main topic for junior high school.

Participans

The participants of this research are the eighth grade students of a junior high school in Bengkulu City in academic year 2012/2013. The participants consisted of one class (32 students) in for a limited test and four class (132 students) for field testing. Each students of each class in field test solved five open ended problems.

Procedure

Procedure of this researchwas modified from the 4-D learning by Thiagarajan, Semmel and Semmel (Trianto, 2011) and the stage of development of assessment instruments by Depdiknas (2004). This research involves three main phases: 1) define, 2) design, and 3) develop. The develop phase is consist of three steps, those are the expert validation, limited test, and field test. The proceduresare shown on Figure 1.

MEASURES

Validity Analysis

The validity of the open-ended problems Draft I was analize by giving a score for each quisionaire item with 1 to 5 scale. Furthermore, the average total validity matched with the validity categories.The problems were said valid, if the average score sheet charging results in a minimum validity of a valid category.

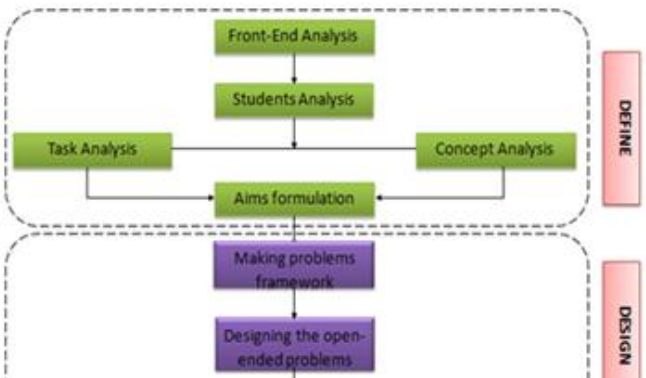

Figure 1. Research Procedures

Practicality Analysis

The level of practicality analysisof *open-ended* problemswas developed based on practicality sheet given to students in the same way the validity of the analysis. It is said practical, if the average score sheet practicality of charging results in the minimum practicality category.

Effectiveness Analysis

The open-ended problems had been solved by students then be analyzed by giving the score for each problems firs.Assessment rubric used in this study based on the *Generic Rubric* by Davy et al (2008) with slight modifications. This assessment rubric uses a four-point scale described in detail indicator response / answer students for each point. It facilitated the detailed elaboration of the scoring in the assessment sosl questions *open-ended* Then Open-ended Problem is said to be effective if: 1)Appears solution answers illustrate the students' ideas; 2)The average percentage of students who achieve the criteria of a minimum of 60 classical completeness is 70%; and 3) Student responses to *open-ended* questions when the percentage of positive responses of at least 70% of students poditif.

Result and Discussions

The results of this study are the open-ended problems in circle main topic for Junior High School. These questions have been validated and tested both limited and field tests in a Junior High School of Bengkulu city. Development of these issues through the development stages of learning starts from the define,design, and develop phase.

Define Phase

Define phase provide understanding and preparation for the process of designing the open-ended problems in circle main topic for Junior High School. Stages started from analyzing the problems encountered in terms of circle main topics materiala, the learning process which was not using *open-ended* problems, and future challenges that

require creativity of the students, also a teacher so an *open-ended* problems were required.

Conditions of students who were accustomed to solve the closed problems and not familiar even tend to dislike essay problems, was the consideration in developing *the open-ended* problems. The average value of the exams in previous semester (that is 65.94) also be additional information to establish minimum standards of completeness that would be one of measurements of the effectiveness of the questions were developed.

Design phase

Design phase produces the first draft of the open-ended problems in circle main topic for Junior High School. The design phase starts from the preparation of the problem framework, and preparation of manuscript matter by observing basic competencies, indicators, contextual issues, supporting information such as images, tables, source material from the student textbook and other relevant sources, as well as about the proper use of language. Design process resulted in the first draft of the questions are *open-ended* question consists of 20 items and has been considered to be used for the next stage of research.

Develop Phase

The develop phaseresult is a final product of the open-ended problems in circle main topic for Junior High School , along with review questions and scoring guidelines that have been revised based on the experts judgement and data obtained from limited testing and field tests. The development process consists of three phases: validation, limited testing, and field testing.

a. **Validation**
   Draft I of the open-ended problems which had been made in the design phase is validated by two experts consisting of one lecturer of Mathematics Education Program and one mathematics teacher of a Bengkulu Junior High School. The analysis of the validity from the validators on the charging instrument validation shows that the first overall draft questions *open-ended* judged "valid" with an average validity of 3.93. The results of the revision of the validation process generate Draft II issues a valid open-ended problems.
b. **Limited test**
   Draft II of the open-ended problems which had subsequently entered the limited test stage. In this stage, Draft II of the open-ended problems divided into 4 groups, each consisting of five questions. Limited test was conducted in eight students for each group of questions in one class.The analysis is performed based on the practicality of charging data if the practicality of a questionnaire by the students showed that the second draft of the questions *open-ended* declared "very practical" and can be applied to students with an average of 4.34 practicality.
c. **Field Test**
   The Field tests conducted after the result of the limited test Draft III of the open-ended problems were practicaable. Draft III is tested on one class that is the subject of study for each of the five problems. The Classes used in this tedt were VIII-5 is the class for about group A, class VIII-3 for about group B, class VIII-2 for the matter of group C, and class VIII-4 forquestions about the group D testing performed at each math each class, except for class VIII-4 carried on after school hours.

The researchers analyzed data about the number of emerging solutions, the data value of the student, and the student questionnaire responses. The number of solutions produced at least two solutions. Data on the number of students' solutions can be seen in the table and graph below.

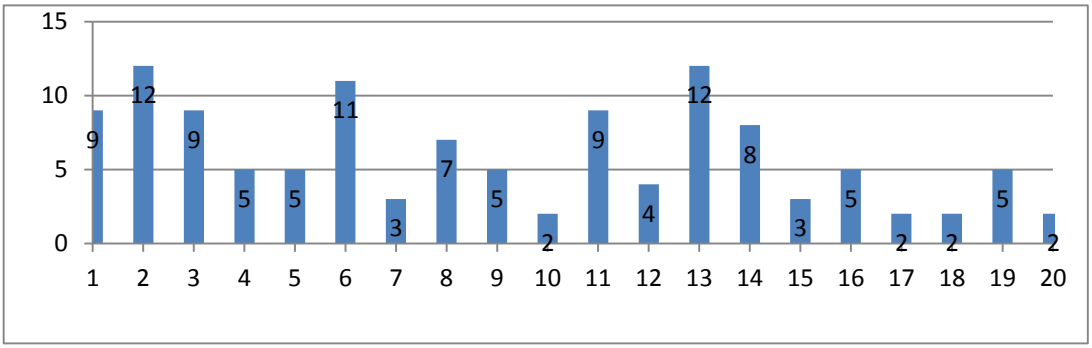

Figure 2. The Variation of students sollutions

The graph in Figure 2 shows that about no.2, 6, 12 and 13 gave rise to a solution which is the highest number among all solutions tested matter. Problem No. 2 led to variations in the length of the minute hand answers. The length of the minute hand on a clock selected by students generally be a number multiples of seven, so the matter can be done easily. This may be because students are accustomed given example problems with multiples of seven figures by both teachers and students.

Creativity of the students was also apparent from some of the students who gave two possible answers to the problem, such asthe problem number 1, 6, and 11. Problem no.1 gives freedom in choosing two of the three types of materials available materials. Setting thenumber of fence sections can be arranged by the student. For example ½ sections for each ingredient or a third part for the first ingredient and 2/3 parts for both materials and so forth. With the creative freedom to do the problems, it can lead students to express more than one possible answer.

Problem no.11 also encourage students suggested many possible answers. If the answer to question no.1 possibility because the use of the phrase and the data are well presented on a matter, a matter no.11 spark students' creativity with the use of images displayed. It presents a picture frame of the fan and the fan that vary both wide angle and center fabric used to encourage students to express more than one possible answer. Issues presented in this matter is very close to the school life of students, as well as any images displayed interesting patterns and favored students. Some students even color the sketches made to resolve the problem. It shows the creativity of the students work on the problems that arise when a given. Students are not the only answer to the two solutions, but also create a beautiful picture. Students who answered questions with two answers is no.11 MSA, MRS, GL, DM, DS, and CDP. In the value data of students, found that these students gain value over 60. This suggests that students with moderate and high ability to perform activities that vary by doing math problems are given *open-ended*.

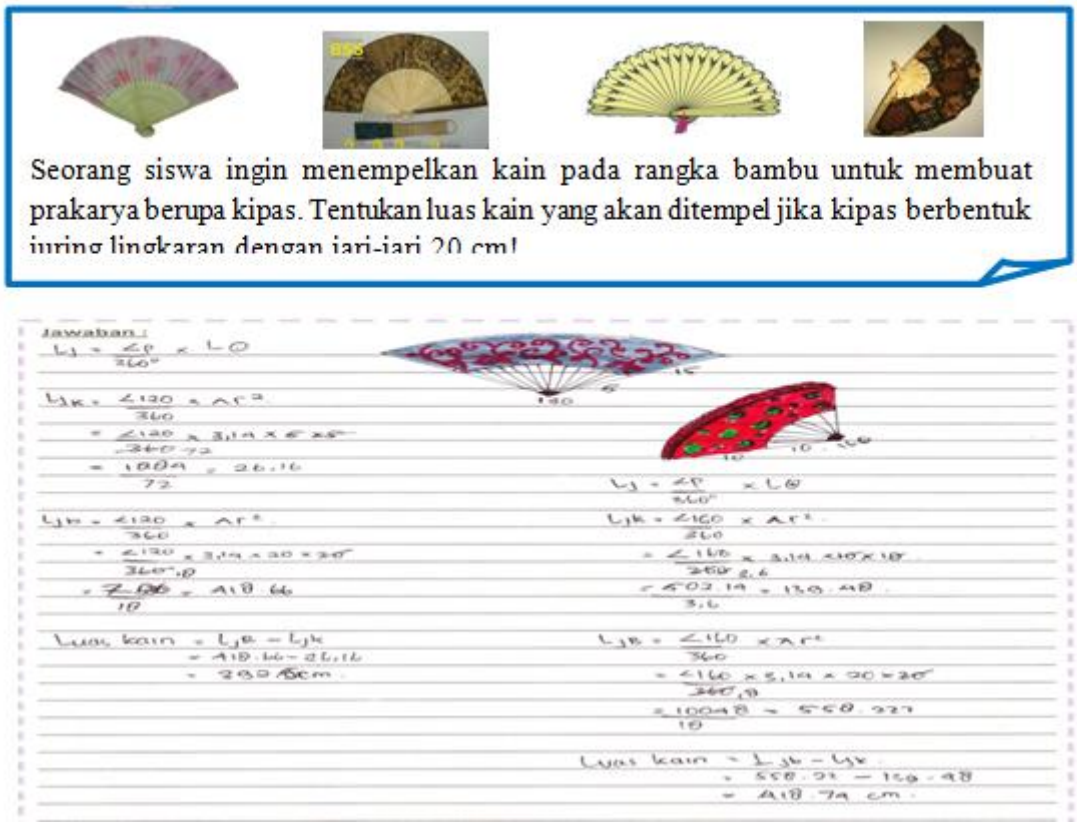

Figure 3.An example of student's solution

Problem no.6 also answered with two possibilities by two students. Students who answered questions with two possible answers no.6 is MZW and MAM. If seen in the data of the students, both the student is in the rank of 23 of the 32 students that MAM with a value of 65 and the last rank is MAM with a value of 32.5. It showed us that students with lower abilities can still enjoy mathematics activity according to their abilities and interests. There is a possibility that they were interested in the issues presented on the Ferris wheel problem. The answer they gave was to use a distance of 120 m with no need to perform the calculation againbecause the answer is 3.14. The both Answer due around the windmill was obtained divisible by 8, so as to facilitate the calculation. Although their reason were simple, yet they still showed the mathematical ability to recognize numbers divisible by eight, other than that they have been able to show two answers, when their other friends show only one answer.

Analysis of student learning outcomes was seen from the percentage of students who achieve achievement score of at least 60. Data of student learning outcomes during field tests of each class can be seen in Figure 4.The average percentage of students completed for the entire class obtained 76.46%, while 23.54% of students do not complete.

It should be discussed from the student's grades is the percentage of students who achieve a score of at least 60 in class VIII-4 is only 54.55%. This is caused by the time the field tests. Class VIII-4 on field tests can not be used during school hours on school mornings. Then the test will be conducted after school. But in the last hour, the class did not study agriculture because the teacher was unable to attend, so the test time is

accelerated an hour before school end, with the expectation of the time spent after school hours may be reduced so that the child does not come home too late. But when the bell rang, the children became bored and wanted to go home, and no longer interested in solving the problems, eventhough still about they still had much time. Because of this, most of studentswere not do the last two questions well, so the effect was on the acquisition value.

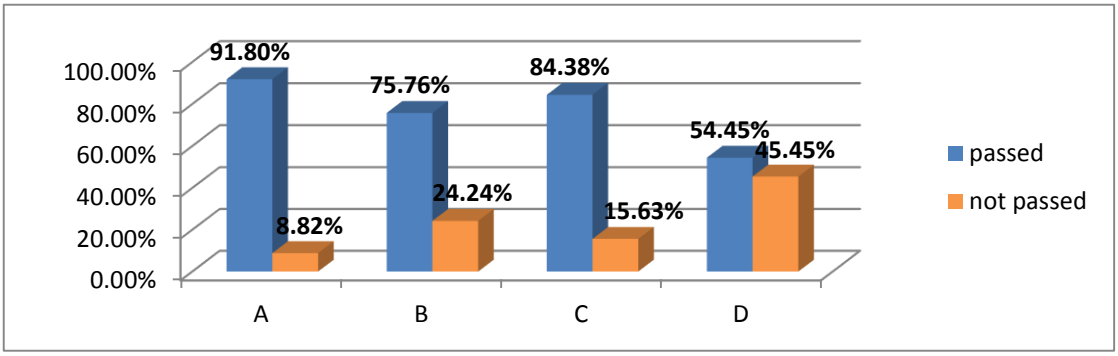

Figure 4. Precentage of the student that achieve the minimum criteria of classical completeness

Analysis of student response data based on the data filling questionnaires by students, obtained an average percentage of positive responses every aspect of more than 70% with an average percentage of 91.5%. It showed that student responses to the Draft III questions are *open-ended* positive. The third aspect of the effectiveness of a matter can be summarized in the following table:

Table 1. Effectiveness Achievement Draft III

No.	Indicator	Information
1.	The diversity of students' answers	Reached
2.	Achievement of learning outcomes	Reached
3.	Students' responses to questions	positive

With the achievement of the three indicators of the effectiveness of the questions *open-ended* are developed, then the Draft III is said to have been effective. The results of the study form the final manuscript of open-ended problems in circle main topic for junior High School are valid, practical and effective and consists of 20 items with the completion of the way a lot of answers and finally obtained.

CONCLUSION

The conclution of this study can be shown as follows.

a. The study had been developed 20 open-ended problems which are valid, practicable, and effective in circle main topic for junior High School.
b. From the study, can be concluded that those open-ended problems can be used for developing the junior high school students' creativity.

RECOMENDATION

a. The problems test stage should be carried out simmultanously in the morning for the whole class. It aims to minimize the difference of students' scores caused by factors that interfere the test process, such as tired, hunger, and boredom factor of students.
b. The open-ended problems can be developed further for other materials and other school grades by notice on the students condition, school, teacher, and material concepts.

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